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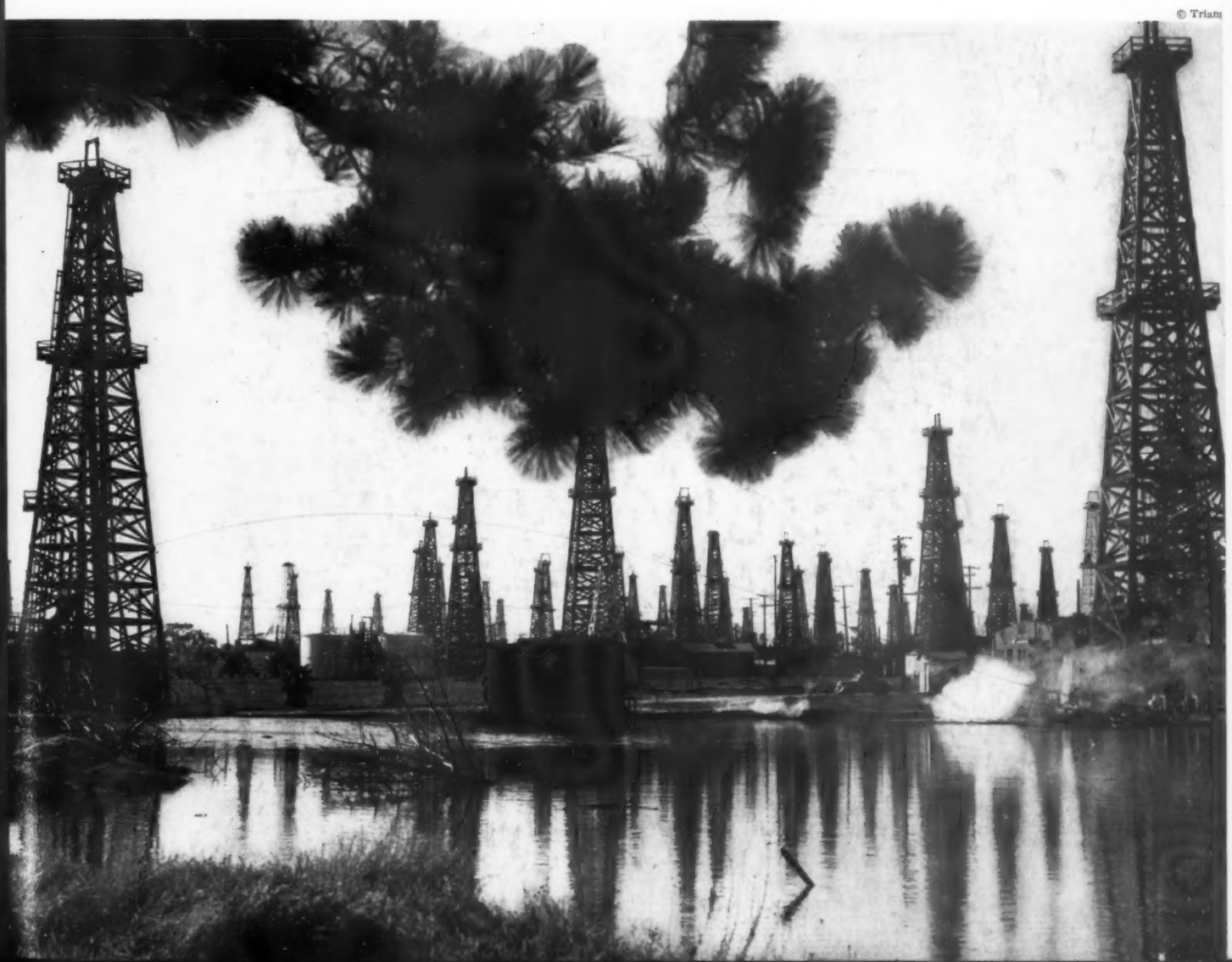
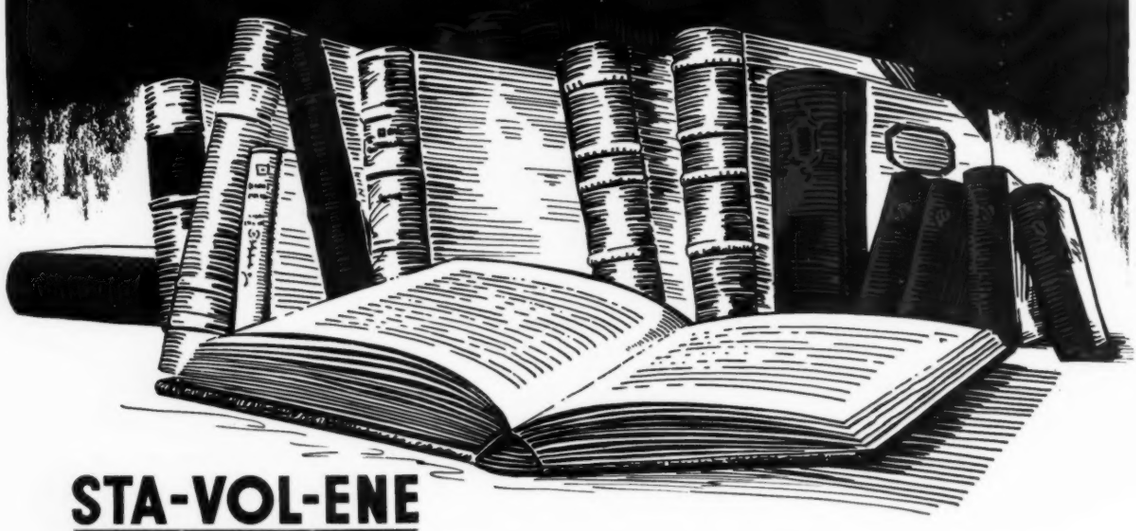


Those Who Know

THEIR NATURAL HISTORY



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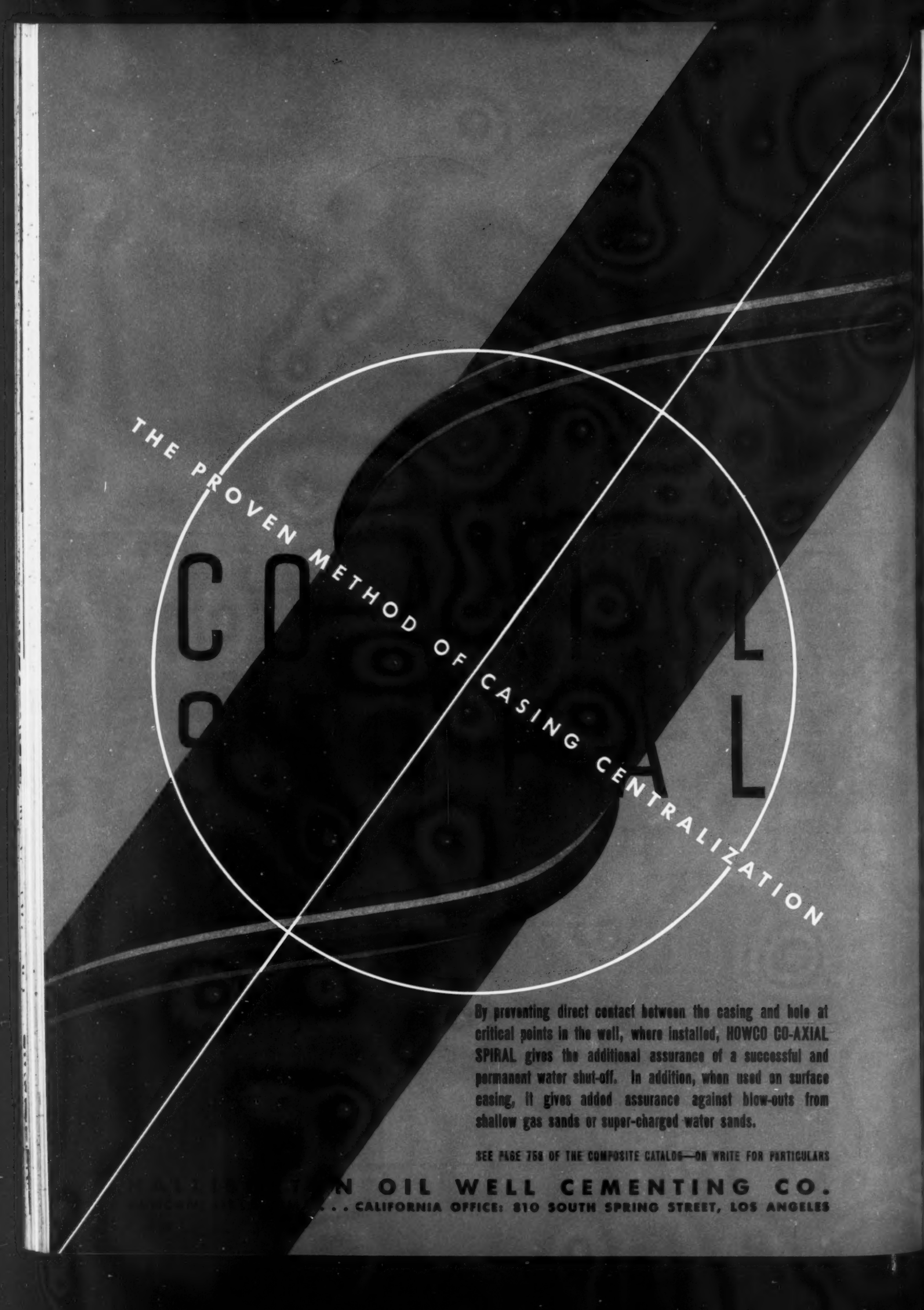

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EDITORIAL

WHY BUSINESS HESITATES

DESPITE drawbacks and handicaps the oil business is a good business. It prospers when other industry prospers. Its risks are greater than those of most other occupations. It is subjected to unreasonable and extortionate taxation. It tolerates trade practices that penalize it heavily. It has one great advantage, however, in that it deals with commodities that have become primary essentials of modern life and industry.

Years ago the motor car ceased to be a luxury. To the present generation it is just as necessary as clothing and shelter. In the United States at least more than 75 percent of all the passenger vehicles in use are owned by persons with yearly incomes of $2500 or less. Motor trucks and buses handle an ever increasing share of all transportation. Oil burning ships and oil burning locomotives traverse sea and land. Oil heats millions of homes and provides power for tens of thousands of factories. Without the lubrication supplied by petroleum the wheels of industry would cease to turn.

Being related so intimately to the wide range of everyday activities petroleum is peculiarly dependent upon other lines of industry. When general business is expanding the demand for its products rises rapidly and prosperity follows. When industrial activity slackens petroleum products immediately feel the effect. Members of the oil industry, from drillers to the operators of roadside pumps, are directly concerned in anything that threatens to interrupt the upward swing in business that has been so strikingly in evidence during the past year.

THAT there has been in recent weeks a recession in trade activity in the United States is evidenced not only by the accepted indices by which the volume of business is measured but also by the reports from individual firms in widely separated sections of the country. This let-up in the forward movement that has progressed so steadily since early in 1936 is more pronounced in some lines than in others. For the first time there has been a definite check to consumer buying as reflected in the weekly reports of mail order houses and large retail establishments. The sharp reversal in the upswing of security and commodity prices is a symptom of developments that are becoming sufficiently widespread to attract attention. In the automobile industry which directly affects the demand for petroleum products the change is less noticeable. Despite the disorganization caused by strikes, deliveries of cars and motor car registrations continue to make new high records. Registrations for the first four months of the year are 10.5 percent greater than in the corresponding period of 1936 and the gain is especially marked in commercial vehicles. If, however, the recession in general activity proves to be more than a temporary lull it is not to be expected that the oil and automotive industries can escape its effects indefinitely. It becomes interesting, therefore, to inquire into the nature and probable duration of the present recession.

IN every era of prolonged business expansion there are occasional temporary setbacks as the forward movement gets going too rapidly in one or another division of industry. The current reaction may be a phenomenon of this sort. Quite clearly the slowing down of demand for many products is due to the inability of consumers to maintain their buying in the face of skyrocketing prices. Employment has increased and wages in manufacturing and merchandising trades have been raised substantially since the first of the year, but purchasing power has not kept pace with the rise in living costs. Commodity prices increased 26 percent in the five months before the reaction which set in at the beginning of May. If this were the sole cause of the halt in activity it would be remedied by a readjustment of prices though it is difficult to see how this can be carried very far in the case of manufactured goods because of the advance in the cost of raw materials, in wages and in taxes. For a long time increases of this kind were absorbed by expanding activity and the consequent decline in overhead, but obviously there is a limit to possibilities in this direction and this limit apparently has been reached in many industries.

Most trade observers, while regarding the present reaction as a temporary one, attribute the hesitation of business and its uncertainty regarding the longer future to causes much deeper than the unbalance between prices and purchasing power. These causes are connected with the fundamental unsoundness of the national financial policy and apprehension as to the measures which the present administration may adopt in its effort to control industry through legislation.

The longer the government tries to maintain its revenues by wholesale borrowing while its mountainous debt grows by billions of dollars yearly the more difficult the process becomes. Significant warnings have been given

by the weakness of government securities which have been kept from falling still lower only through buying by the government itself. Its policy of buying silver and gold at prices above their real market worth as measured by what any other nation is willing to pay imposes an added burden which has been increased of late by the "sterilization" of gold purchases. The imposition of new taxes that penalize business growth and efficiency has failed to provide the additional revenues which their official sponsors anticipated. While lavish government spending has created temporarily an artificial purchasing power the net effect of all these various factors is to make it more and more difficult to avoid uncontrolled inflation with all its disastrous consequences.

More serious still in the long range outlook is the determined purpose of the administration to alter the form and function of the American government in order to make possible a control of individual action and enterprise such as has been attempted heretofore only under extreme forms of autocracy. The attempt to reduce the judicial branch of the government to the position of a mere mouthpiece of executive opinion has profoundly disturbed intelligent citizens. One reason is the undisguised purpose to clear the way for laws imposing the will and theories of a little group in Washington upon all branches of industry. A second is a realization that the success of this effort will remove the last effective barrier to usurpation by a federal bureaucracy of the rights of the states and of private citizens under the Constitution.

THE hesitation of industry to move forward confidently in supplying needs and demands that are far from being satisfied unquestionably is due largely to realization that the financial policy now being pursued at Washington is bound to entail disastrous consequences and to the lack of any evidence of serious intention to curtail or revise that policy as the danger draws nearer. If present conditions are allowed to continue these set backs to recovery will recur more and more frequently. Business possesses astonishing vitality, astonishing power of adaptation to difficult conditions and almost crushing burdens. The one thing to which it cannot adapt itself is the unknown. So long as uncertainty remains as to whether it can continue to operate under the rule of law or must subject itself to the varying whims of a single individual its hesitation to embark upon new undertakings is both understandable and unavoidable.

DRILLING PROGRESS A FACTOR IN CONSERVATION

WHEN every well drilled leads to production and when methods of producing reach the point where all the oil in a given field can be recovered we shall have reached an ideal state, ideal at least from the point of view of the oil producer. Since perfection, we are told, is never realized on earth it is improbable that this goal ever will be attained. Within the comparatively brief history of the oil industry, however, we have made substantial progress in this direction and there is no doubt whatever that further advances will be made in the next few years.

Improvement in the art of drilling and in the machinery and tools provided for the driller has been so gradual and so continuous that it is difficult to measure progress from year to year. Looking back over a period of ten, fifteen or twenty-five years, however, one can but marvel at the improvements made in every phase of the business.

Noteworthy and encouraging as have been the improvements in drilling and production nobody familiar with either the theory or practice of drilling believes that progress has reached an end. In fact the engineers who are most familiar with the subject are most keenly alive as to the need of more efficient methods and equipment. Drill pipe failures still occur, time-consuming fishing jobs are all too frequent incidents of drilling, much too large a proportion of the wells drilled still result in dry holes. We have published numerous articles and expect to publish more dealing with deficiencies in the manufacture and management of drilling equipment. New demands for stronger and more dependable materials and machinery arise as wells go deeper and deeper. Working in harmony, however, the men in the laboratories, those in charge of the fabrication of tools and those who use drilling equipment in the fields will continue to make steady advances and to increase the world's available supply of oil by making more complete the recovery of those deposits which human ingenuity is able to locate and tap.

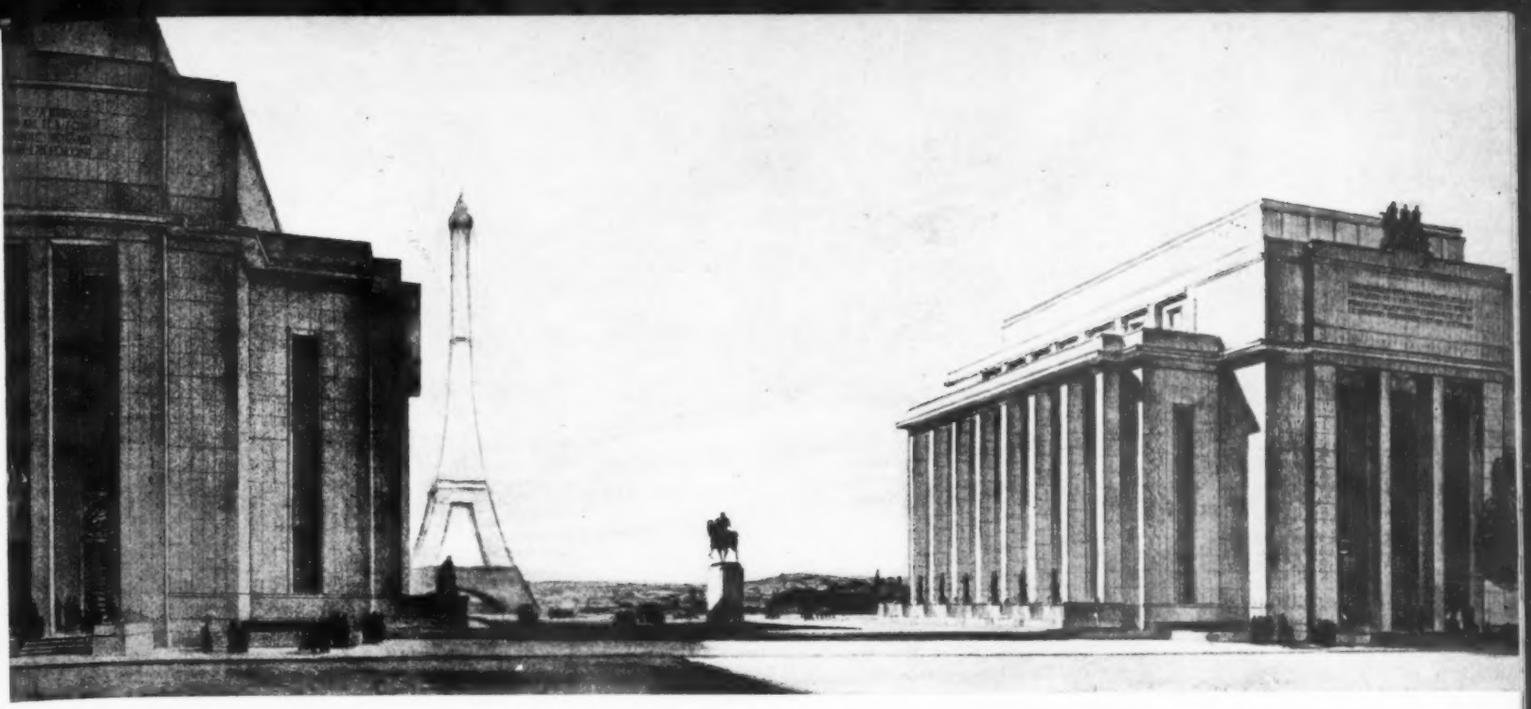
JOHN D. ROCKEFELLER

JOHN D. ROCKEFELLER, founder of Standard Oil and for many years the most outstanding figure in the oil industry, passed away at his Florida home near Ormond Beach, Sunday, May 23. He was approaching his ninety-eighth birthday which would have been reached on July 8 next.

Although a quarter century has passed since Mr. Rockefeller withdrew from active participation in petroleum affairs no other man has left his impress upon the industry to a like degree. When he began trafficking in oil it could hardly be called a business, so disorderly, wasteful and ill-directed was it. Although it had been in existence only a few years it was cursed with overproduction, overcompetition and lack of efficiency in all its processes. Not infrequently the cost of transporting a barrel of oil fifty miles from the well was more than the value of the oil itself. Products of refineries were far from uniform and in some cases actually were dangerous to use. Marketing in the modern sense of the word was still to be developed.

The debt of the oil industry and of the world at large to John D. Rockefeller is that he led the way in changing these chaotic conditions. He hated waste. He worshipped efficiency. He had the patience to work out the details that mark the difference between a successful and an unsuccessful business. Though without technical training he early appreciated the importance of research in improving the processes of handling crude oil and multiplying its products. He had a broad vision of a great world industry built upon oil.

Through his ability as a financier, organizer and coordinator he set the oil industry upon the road to greatness and broad service to mankind. The bitterness that attended the early struggles within the industry has long since died out. The solid results of his life work remain as an enduring monument.



Buildings under construction for Paris Exposition which will be opened for the World Petroleum Congress.

SECOND WORLD PETROLEUM CONGRESS Convenes in Paris

ON JUNE 14–19 there will be a notable gathering in Paris of leading personalities of the petroleum industry to exchange experiences and viewpoints relating to all phases of this far-flung business.

It will be the second of such assemblies, the first having been held in London in 1933. At that meeting the resolution was taken to make the World Petroleum Congress a triennial affair, but certain circumstances arose that made it advisable to postpone the second meeting to 1937. This delay is more or less welcome, as it will afford the participants an opportunity to see the International Exposition that will be held this year in Paris.

Arrangements for the Congress have been made by a large committee of l'Association Francaise des Techniciens du Petrol, an organization which includes in its membership many of the chief figures in the French petroleum industry. Under the chairmanship of Ch. Bihoreau, with J. Filhol as secretary, it has been in touch with hundreds of representatives of the oil industry throughout the world and has received assurance that numerous and varied papers will be presented. This work of the central committee has been supplemented and amplified by national committees in the various oil countries. Among the organizations that have tendered their collaboration are the Institution of Petroleum Technologists (London), the American Petroleum Institute, the American Association of Petroleum Geologists, the National Petroleum Association of Poland, the Roumanian National Committee for Drilling, the Roumanian Association of Petroleum Industrialists, the German Society for Mineral Oil Research, the Austrian Petroleum Institute, and others. Up to the middle of May more than 300 communications had been received by the Secretariat. The number of participating countries will most likely exceed thirty.

The proceedings of the Congress will be arranged in five Divisions, each with an outstanding French oil man as Chairman, as follows:

Geology and Drilling (Galliot).
Physics, Chemistry and Refining (H. Weiss).
Materials and Construction (L. Chové).
Utilization of Petroleum Products (P. Dumanois).
Economics and Statistics (M. Mercier).

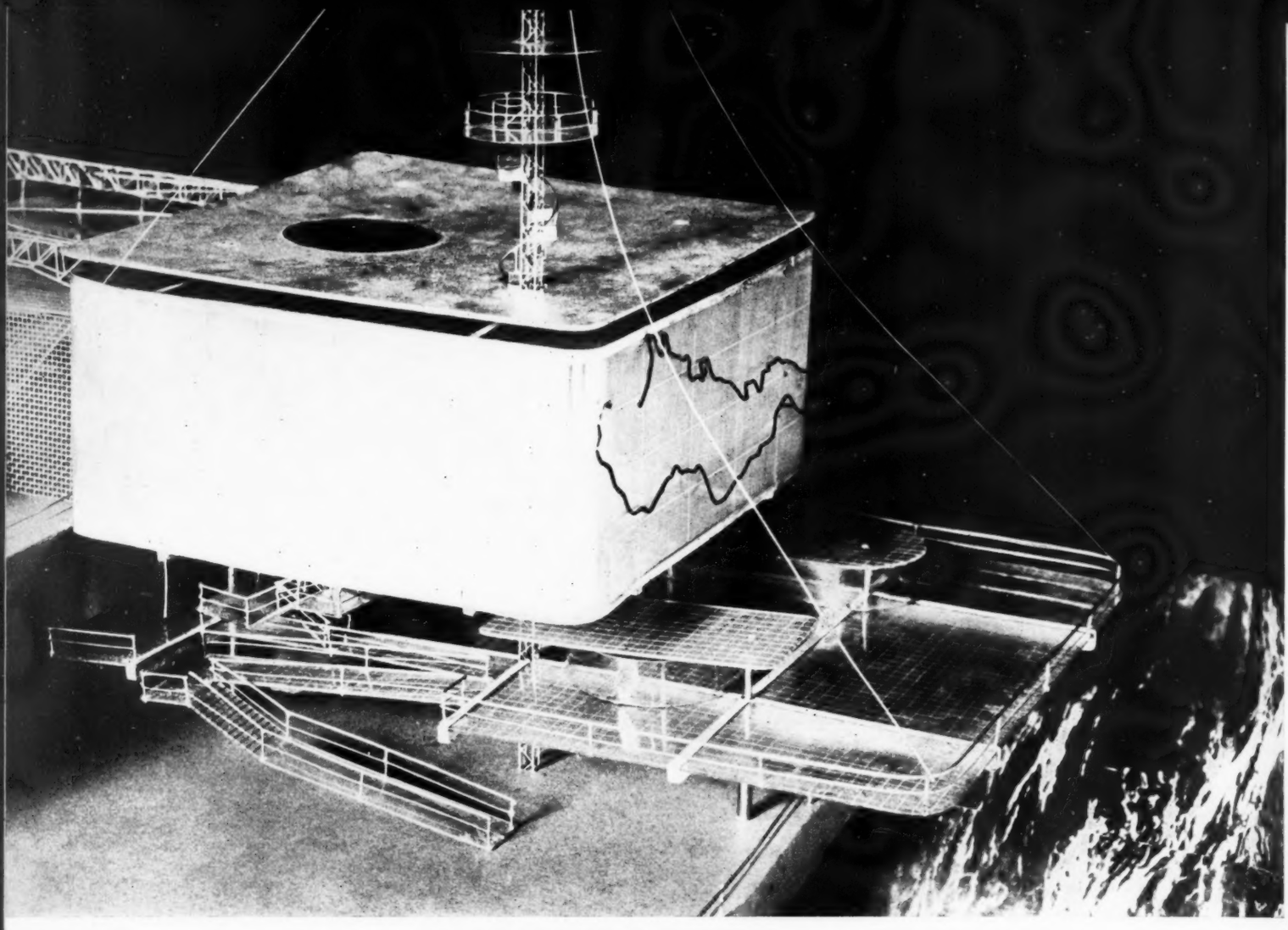
The program arranged by the committee on Geology and Drilling has been grouped under four subdivisions to include Geology, Geophysics, Drilling and Production, and within these broad groups provision is made for the reception of communications on a wide variety of subjects, covering, in fact, all the main questions in which oil men are interested, whatever their particular calling may be.

Geological papers will be classified in three groups: field work, laboratory work, and comparative regional geology.

Geophysics has six divisions: gravity methods, seismic methods, electric and electro-magnetic methods, magnetic methods, miscellaneous methods (geothermy, radioactivity, etc.) and methods applied in wells (electric logging, etc.).

Drilling will include 11 subdivisions: deep

Belgian building at the Paris Exposition.



Modern design characterizes the buildings of the Paris Exposition.

drilling, directional drilling, pressure drilling, drilling muds, well control apparatus, cementing, steam power drilling, the Diesel motor in drilling, the electric motor in drilling, portable rigs, and progress in drilling equipment.

Production has seven subdivisions: flowing production (as affected by pressure, oil-gas ratios, etc.), practical application of well data and metering; production by pumping, reconditioning oil fields by water, gas or air and acidizing; separation of oil and gas, treatment of emulsion, fatigue and corrosion of tubing, well spacing.

In addition to papers submitted by individual authors on subjects of their choice, the Committee has arranged for the presentation of a general report relating to geology and drilling in each country, reflecting conditions as they exist in 1937. These general reports will include historical and statistical details relating to discovery and exploitation of oil deposits. To date 13 of such general papers have been announced from Germany, Austria, Canada, United States, France and Possessions, Great Britain, Dutch Indies, Iraq, Iran, Mexico, Poland, Roumania and Czechoslovakia.

The total number of communications offered in this Division has reached 82 with the prospect that the number will exceed the number of papers presented at London.

The principal aim of the committee in charge of this Division has been to cover the progress made since the London Congress in 1933, and the committee has issued special invitations for papers on natural gas and its utilization; paraffin and dewaxing; solvent refining; tars and bitumens and their preparation for various uses; motor fuels and synthetic petroleums; also methods of refining with particular reference to gasoline, gas oil and lubricating oils. In order to make it easy for non-specialists to appreciate papers on these technical subjects the committee will make a general summary of all the principal questions that come up before the Division. A general discussion of solvent refining has been prepared by M. Klinkenberg of the Bataafsche Petroleum Mij., and a general report on bitumens has been prepared by Messrs. Vellinger and Radulescu.

The text of all papers presented to the Division will be preprinted and the meetings will be given over to discussions. These discussions, under the guidance of five rapporteurs, will give emphasis to the following subjects: natural gas (Ballet and Sigwalt); paraffin (Valli-Douan); bitumens (Graetz); synthetic products (Jacque), with other details to be announced.

The numerous papers already received assure that the meetings of the Division will have high scientific and practical value.

In making up its program the committee in charge of this Division has endeavored to avoid dissipation of the time of the participants by a multitude of questions that may arise under this heading, and has invited authors to give prominence to "problems that stand in the focal point of contemporary interest." However, welcome is given to any original paper on a pertinent subject. The subjects proposed for this intensive treatment are:

1.—Construction of apparatus operating at high temperatures and pressures in the oil industry, particularly installations for cracking and reforming.

2.—Efforts to combat corrosion; aside from its general importance to all petroleum technologists this question is of great interest to refineries working on corrosive crudes like those from Iraq.

3.—The struggle to keep down losses in production, which is of importance everywhere and particularly where petroleum products are made the objects of heavy taxation.

The discussions on these subjects will be led by special rapporteurs. All papers will be preprinted and in the hands of the participants before the meetings. Numerous communications have been received already, notably from Germany, Holland and France.

The program of this Division has been made up mainly in view of the fact that the focal point of interest in the oil industry now centers on gasoline as a motor fuel, with gas oil and the Diesel engine likely eventually to claim a large place in automotion, particularly if the heavier fuels continue to enjoy a relatively light burden of taxation. The possible future expansion of aviation is also a factor to be reckoned with. A chief place in the proceedings of this Division will therefore be taken by questions of automotive engines, horsepowers in relation to weight and radius of action; special motors operating on special fuels, improved lubricants that allow increased speeds of revolution, etc. The key note of much of the discussion will be: not necessarily to demand more performance from the fuel, but more from the engine, with the object of arriving at an engine that will give a better performance with a fuel of lower quality; the interrelations of fuels and lubricants and the engines in which they are to be used will be emphasized.

This Division relates to matters that were largely avoided at the London Congress with the object of keeping clear of subjects that at the time were regarded as more or less taboo, such as international oil politics, autarchy, international petroleum law in wartime, etc. For the Paris Congress this rule has been somewhat relaxed so as to admit subjects that are still within the competence of an assembly without diplomatic attributes, while avoiding discussions of purely hypothetical matters and also matters which are of merely transitory interest. The committee has therefore more or less definitely directed the discussions toward certain general themes, such as:

The juridicial, fiscal and tariff status of petroleum in the world;

The technical and industrial nomenclature of petroleum;

Methods of measurement and the calculation of statistics;

Technical petroleum education;

Geography of petroleum;

History and archaeology of petroleum;

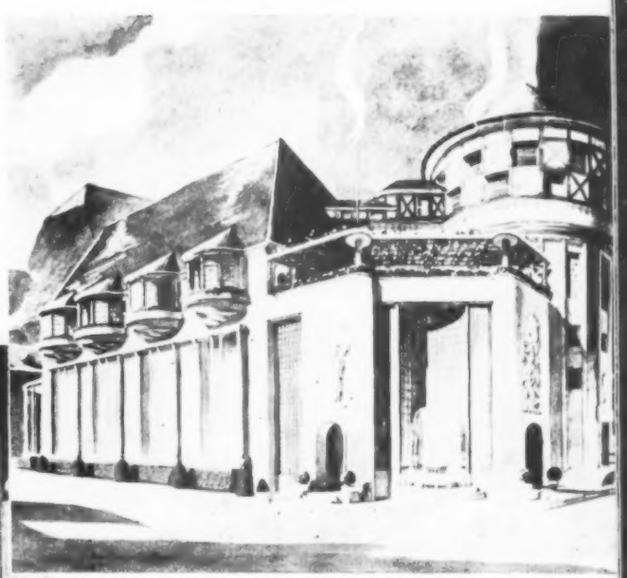
The general bibliography of petroleum;

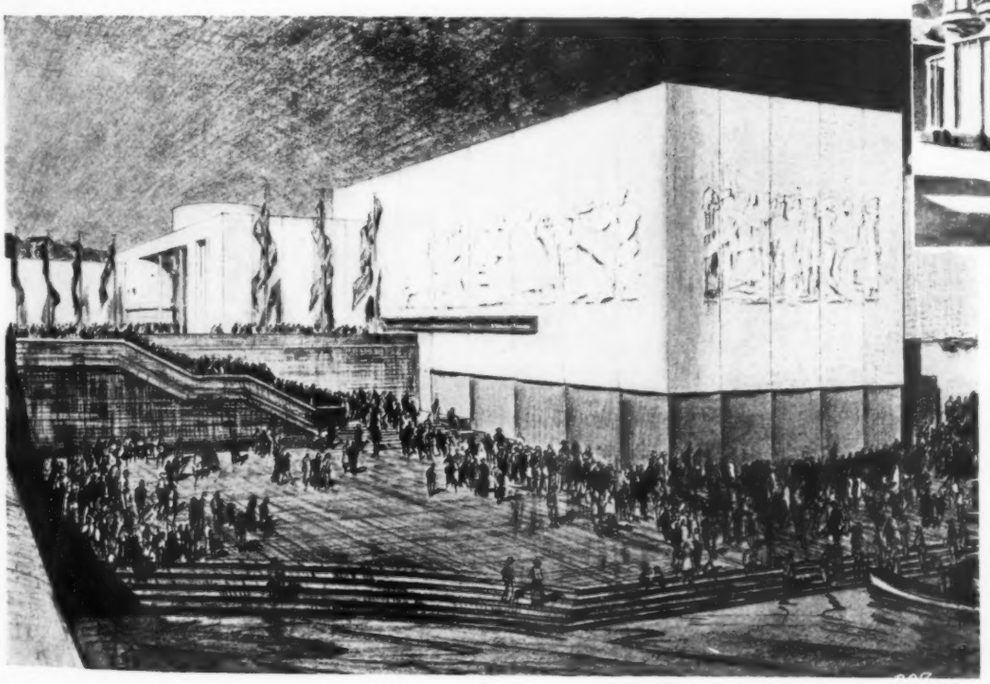
General economics of petroleum, including production, transport, treatment, distribution and consumption of oil products.

This program will include all matters of a general or universal nature, leaving the discussion of particular scientific or practical matters to the other Divisions. Numerous papers of this nature have been received.

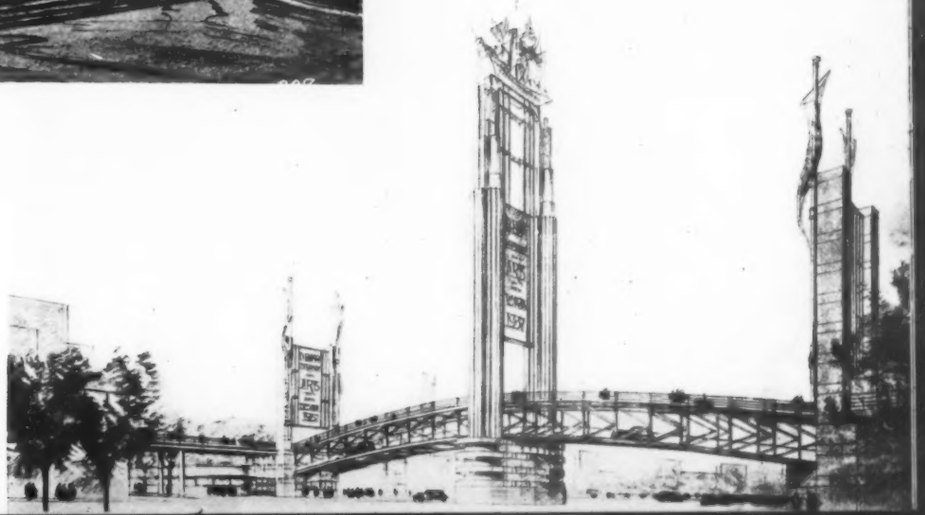
For those who reach Paris a week before the Congress an excursion has been arranged for a visit to the Morocco oil fields; on the return trip the excursionists will visit the refineries in the south of France. Arrangements have been made for four other excursions after the Congress of which one will take in the refineries of the lower Seine and Normandy, the second will be to the Courchelettes plant in North France, and the hydrogenation plants at Bethune and Lievin, the third to the Pauillac refineries in Bordeaux and the fourth to the Pechelbronn oil region. There will be a number of receptions and other entertainments.

Members of the industry attending the World Petroleum Congress will be admitted to the Exposition.





While many of the buildings at the Paris Exposition are not yet completed, work is being rushed to permit opening during June.



RECORD NUMBER OF WELLS

Being Drilled in 1937

Statistics Show Need of Continued Intensive Campaign of Exploration and Drilling to Meet Growing Demand and Maintain Reserves.

FOR THE past several years the emphasis in discussions of oil industry problems has been placed largely upon the dangers of overproduction and overdrilling. When crude was selling at 25 cents a barrel or less it was natural that this should have been the case. Even since the crude price advanced to a more satisfactory level the constant tendency in the larger fields to overrun carefully estimated requirements has continued to focus attention upon this phase of the subject.

That there has been overdrilling of proven fields is beyond question. East Texas of course has served as the classic illustration of this condition and the debate as to how many unneeded wells have been put down in that area and what number would suffice to produce the field thoroughly and economically probably will prove endless. Where the system of proration is based on the number of wells this overdrilling has come to the point of constituting a real danger to producers since each new well results in a reduction of the average allowable. In East Texas itself and in some other Texas fields the per well allowable is now down to such a low figure that any further decrease will make it unprofitable to operate a large proportion of the wells.

The problem of adopting a system of proration not based primarily on the number of active wells that will be equitable to all producers is one that raises many knotty questions. The literature of the subject is enormous and there is no intention to discuss this branch of the subject here.

When oil field operations in the United States are viewed in perspective, however, the drilling situation assumes a somewhat different aspect. The question then becomes one of enabling production to keep pace with the ever mounting demand for petroleum, while maintaining a safe margin of reserves, and suggests the need of an intensified campaign of exploration and drilling in order to preserve a proper balance between supply and demand and to prevent the specter of a future oil shortage from approaching closer than it is at present.

As this is being written production has just touched a new high peak above 3,500,000 bbl. daily; crude stocks and gasoline supplies are both at high levels for the year, and oil men who have been hoping for a further strengthening of prices are certain to become impatient of any suggestion of concern over the adequacy of output. For the moment that is a sound position and it is only the confidence that is felt throughout the trade in a further large increase in consumption during 1937 that prevents the present situation from being regarded as a threatening one. Viewing the situation in its broader aspects, however, this condition may be regarded as a temporary one.

Since there is no fixed standard for the production or the life of an oil well or an oil field it is of course impossible to say in advance how many wells will need to be drilled or how many new fields discovered in order to keep up with the growth in demand and prevent the depletion of reserves. Some indication of requirements along this line may be gleaned, however, from past experience.

In the two years from January 1, 1935, to January 1, 1937, the number of productive oil wells drilled in the United States was 33,307. According to a revised estimate published in March last by the Committee on Petroleum Reserves of the American Petroleum Institute production during these two years was 2,044,000,000 bbl. while 886,000,000 bbl. were added to reserves. In the opinion of this distinguished group of experts, therefore, the fields uncovered by these 33,307 wells represent an addition of 2,930,000,000 bbl. to the past and prospective output of oil in the United States. As demand is increasing at the rate of 100,000,000 bbl. or more yearly 1,135 new wells, on this basis, would be required to take care of the annual increase alone and 15,000 productive wells would be needed to supply the demand for the current year. As previously stated one can only guess as to the potential output of the group of new wells brought in during any one year. How widely these guesses may vary is indicated by the fact that the American Petroleum Institute committee already referred to found it necessary to revise its original estimate as to probable production of the new wells drilled in 1935–36, practically doubling the figure first arrived at and raising it from 1,477,000,000 bbl. to 2,932,000,000 bbl.

Table I, accompanying, gives the figures of the United States Bureau of Mines for oil well drilling during the past eleven years. As may be seen from this compilation drilling activity in 1936 was 11.8 percent greater than in 1935. The number of wells drilled was greater than in any year since 1929. While the Bureau's statistics include gas wells as well as oil wells the gas wells have been eliminated in the present comparison.

TABLE I

Year	Productive Wells Completed	Dry Holes	Total
1936	18,199	5,192	23,391
1935	15,108	4,911	20,019
1934	12,512	4,312	16,824
1933	8,068	3,312	11,380
1932	10,444	3,659	14,103
1931	6,788	3,659	10,447
1930	11,640	6,734	18,374
1929	15,572	7,914	23,486
1928	12,526	7,078	19,604
1927	14,442	7,210	21,652
1926	19,013	7,965	26,978

During the first three months of 1937 drilling has proceeded at an accelerated rate. In January 1937 the number of productive wells completed was 1,580 and the number of dry holes 472. In February 1,366 producing wells were brought in while 413 were abandoned as dry holes. In February 1936 the number of producing wells completed was 1,018 and the number of dry holes was 318. For the full year 1937 it appears probable that close to 30,000 wells will be drilled. If these wells equal the average of those drilled in 1935 and 1936 some further addition to the country's reserve should result.

Befitting its predominant position in oil production, Texas is far ahead of any other state in drilling activity. Of the 23,391 wells drilled in 1936 Texas accounted for 12,520 or 53.5 percent. Within the state East Texas lost the position of leadership which it had held for several years but still had 2,620 completions against 4,120 in 1935. South Texas moved into first place with a total of 3,316 wells. East Texas was second and North Texas was third with 2,175 completions. West Texas and the Gulf Coast followed next in order.

After Texas the states in which the greatest amount of drilling took place last year were Oklahoma and Kansas with 2,850 and 1,720 completions respectively. California was fourth with 1,122. A marked increase in activity occurred in the eastern states with a total of 2,955 wells. Louisiana and the Rocky Mountain area both showed large proportionate gains in 1936 as compared with the year preceding although the total number of wells drilled was much smaller than in any of the states previously named.

During 1937 Texas undoubtedly will maintain its relative position in the forefront of drilling activity and the number of wells put down in the state probably will reach a total of between 14,000 and 15,000. South Texas, West Texas and North Texas probably will be the scenes of most intensive operations. Drilling in Oklahoma is expected to be on about the same scale as last year while Kansas probably will show a substantial increase. More wells will be drilled in California than were put down in 1936.

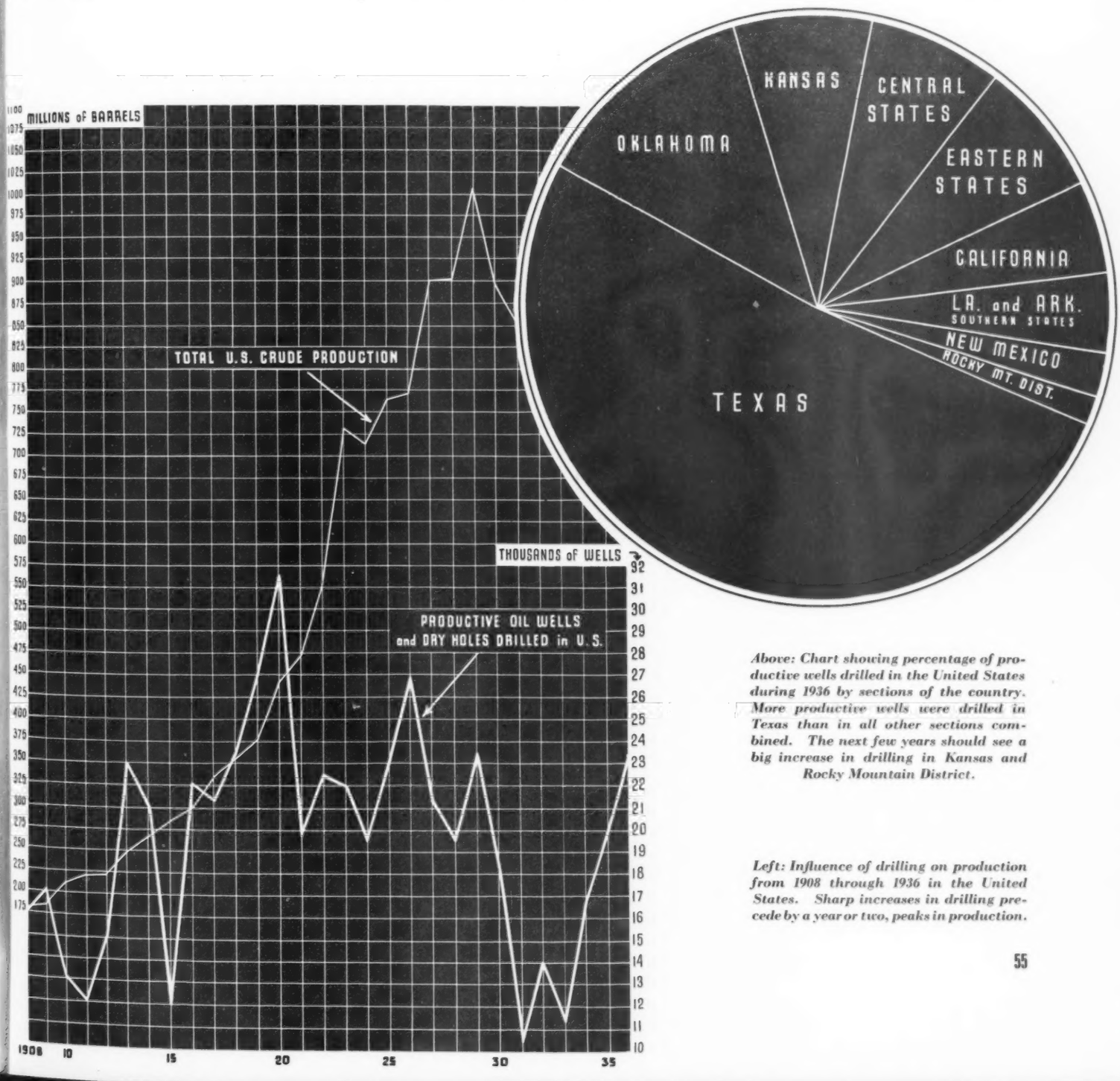
Operations in the Rocky Mountain states are expanding and South Louisiana is another area where a considerable gain is expected. Revived activity in Michigan and Illinois will add to the showing of the eastern states while in the southeastern area an extension of operations is taking place along the Gulf Coast east of the Mississippi although it is not likely to affect materially the sum total of the country's drilling.

One deduction that may safely be drawn from a study of drilling statistics in the United States is that the greatest incentive to exploration and wildcatting is a rise in the price of crude. The very peak of drilling was reached in 1920 when crude was selling at $3.50 per bbl. In that year 24,273 producing oil wells were put down and 7,364 dry holes. As the price dropped in the following years activity decreased. A secondary peak was reached in 1926 with $2.00 crude when 19,013 productive wells and 7,965 dry holes were drilled. This figure of successful completions has not been equaled since though it was closely approached in 1936 and very possibly may be surpassed in 1937 although the price of crude is still far below its 1926 average.

Another factor influences the extent of drilling activity and prevents it from reflecting exactly and fully the fluctuations in the price of crude. Whenever a great new flush field is opened it brings with it a feverish spurt of drilling activity due to the necessity which leaseholders feel of obtaining their full share of the oil which the field contains. In 1926 several large fields were opened and this fact undoubtedly accounted in part for the large volume of drilling in that year. In the early thirties, although the price of crude was abnormally low, the rapid development of the East Texas field, then under way, could not be stayed by this consideration. It is noteworthy, however, that in 1931 the total number of wells drilled was less than half the average number put down during the five years preceding.

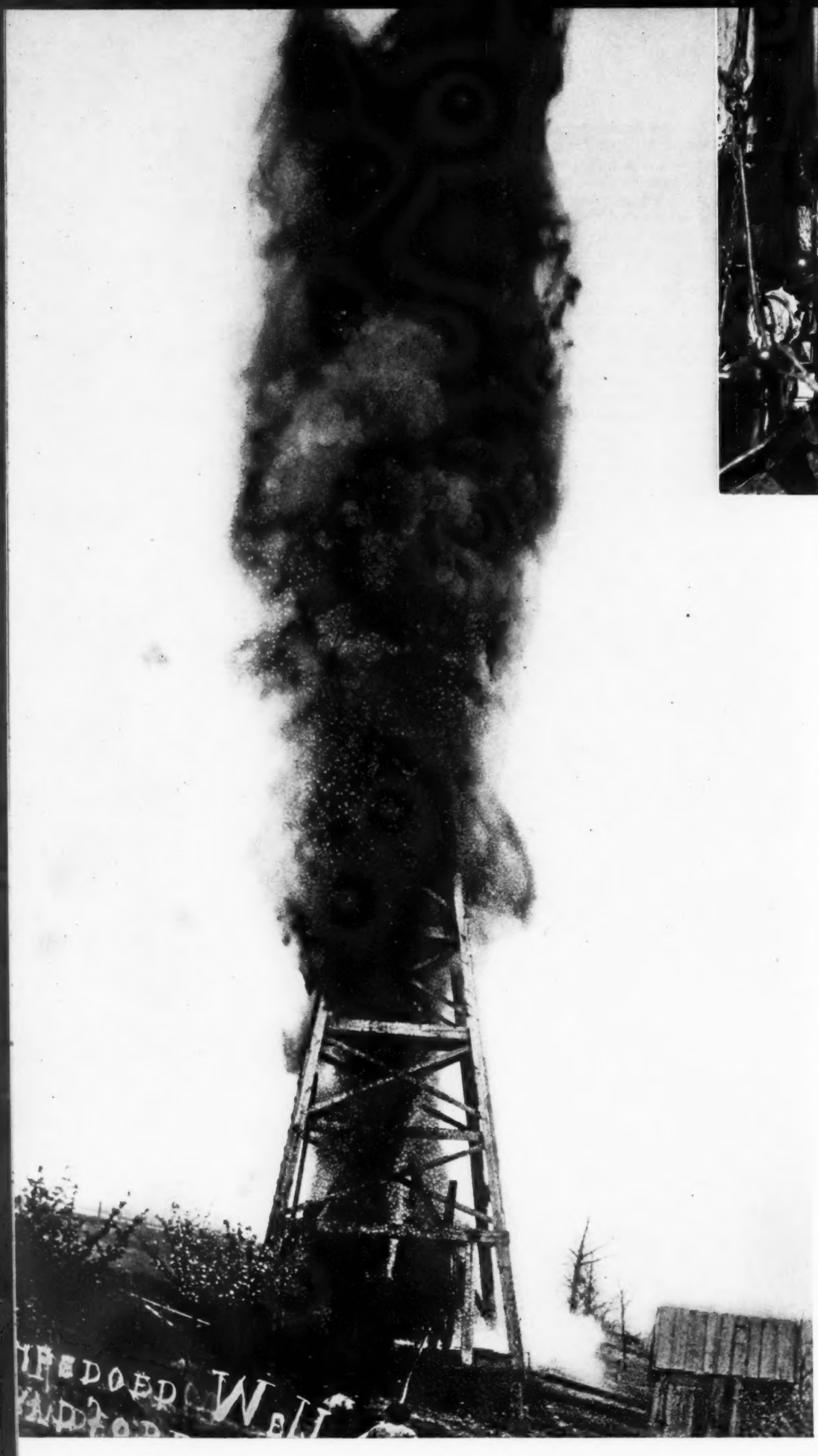
At the present time there is neither a high market price nor the need of developing an important flush field to stimulate exceptional drilling activity. There is, however, a greater appreciation than perhaps has ever before existed of the importance of building up reserves to meet a demand that is rising rapidly. This consideration undoubtedly accounts for the attention that is being devoted, particularly by the larger companies, to expanding their leases and land holdings and to pushing forward their exploratory operations in all areas that appear at all encouraging.

Even though the number of wells drilled during 1937 exceeds the record of any



Above: Chart showing percentage of productive wells drilled in the United States during 1936 by sections of the country. More productive wells were drilled in Texas than in all other sections combined. The next few years should see a big increase in drilling in Kansas and Rocky Mountain District.

Left: Influence of drilling on production from 1908 through 1936 in the United States. Sharp increases in drilling precede by a year or two, peaks in production.



© Cy-La Tour

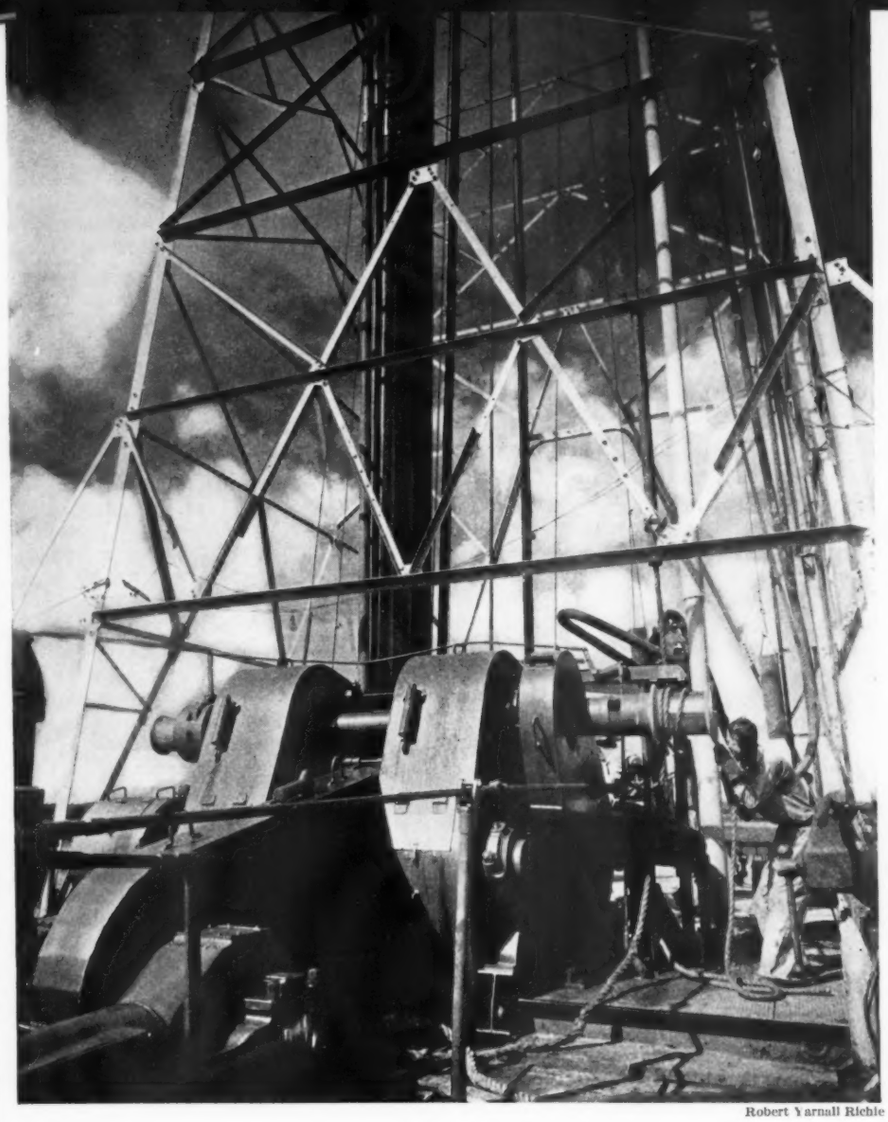
Above: Drilling in California. Right: Modern equipment permits commercial exploitation of deep productive sands, adding to total available reserves.

previous year during the past decade the extent to which these will add, if they add at all, to the country's known reserves remains an unknown quantity. The unpredictable character of individual wells is such that it makes any estimate based on numbers largely a matter of guesswork. In this respect the number of new fields opened is sometimes suggested as a more reliable index than the number of wells drilled. A new field may be confined, however, to the original discovery well or it may provide place for hundreds or even thousands of wells. These factors of uncertainty cannot be eliminated in an attempted survey of the drilling situation.

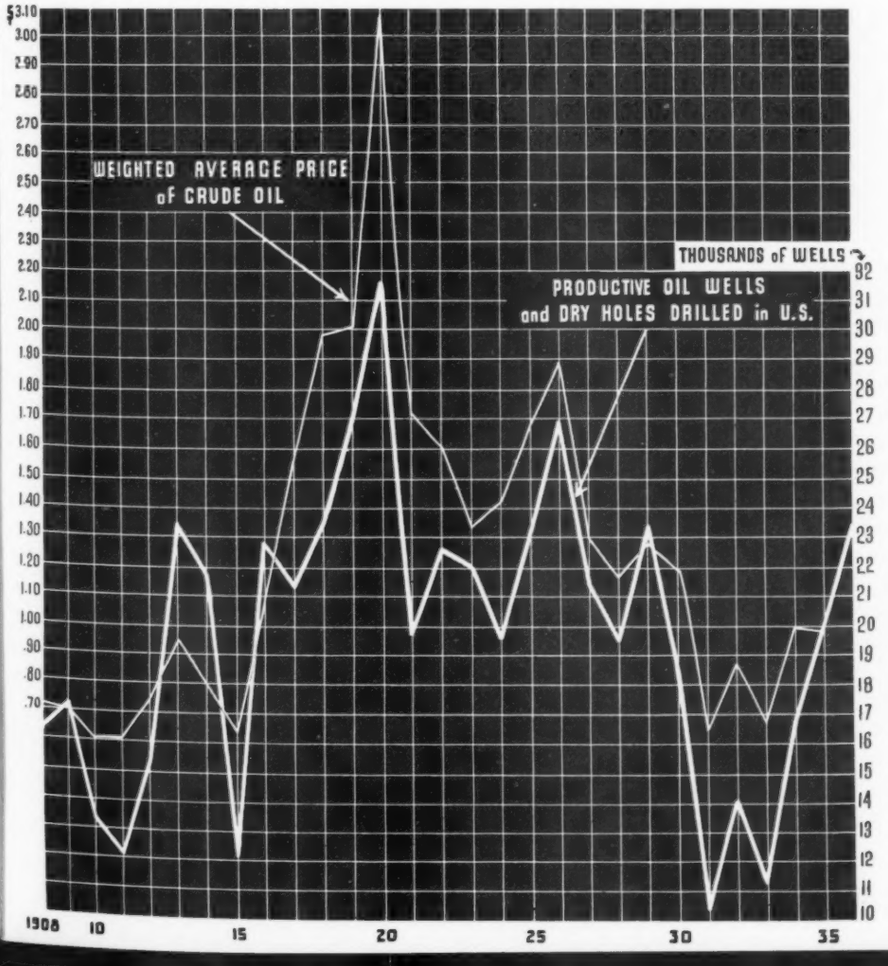
In addressing a meeting of oil men at Tulsa in December 1936 Alexander W. McCoy, well-known geologist of Ponca City, Oklahoma, presented an estimate of drilling requirements for the next five years in order to meet current demand and maintain reasonable reserves. For 1937 and 1938 he computes the need of new discoveries at 2,000,000,000 bbl. and for the following three years he places these requirements at 5,000,000,000 bbl. These figures are based on the assumption of an average annual demand in the United States of 1,250,000,000 bbl. yearly. The author of course claimed for his forecast only such authority as derived from a careful study of the subject.

One noteworthy development in drilling operations in recent years has been the decreasing number of dry holes in proportion to productive wells. Since 1929 the percentage of dry holes in the total number of drillings has declined from 30 percent to a little over 20 percent. Other conditions being equal the natural assumption would be

Left: Well roaring in at Pithole in the 70's from an old photograph taken at the time. Right: Close correlation between price of oil and drilling activity.



Robert Yarnall Richie



that as more and more fields were discovered the difficulty of locating new ones would become greater and the number of dry holes would increase.

That this has not been the case has been due to improved methods of prospecting and particularly to the general adoption of geophysical methods of survey. The growth of geophysical operations has been perhaps the most significant single development of the past three years in the oil industry and it is conservatively estimated that the expenditure on this line of work during the current year will run from $20,000,000 to $25,000,000.

Not only have more scientific methods of locating favorable structures come into vogue during the past decade but improvements in mechanism and technique have reduced the number of wells lost through mechanical and human failure. Higher speeds have cut down the time and cost of drilling. Stronger materials and better design of bits, drill pipe and casing have made it possible to penetrate formations that formerly resisted the strongest attacks of drillers. Maintenance of a straight hole is no longer a lucky accident. Controlled directional drilling has opened new possibilities. Progress in cementing and in the handling of fluids has led to better control and to the prevention of blow-outs. The ability to perforate casing at any desired level saves many wells that once would have been abandoned. In numerous ways such as these the efficiency of drilling has been increased and the penetration of deeper and deeper horizons has been made possible.

The last mentioned development is one of importance for the future. It is safe to say that most of the shallow fields have been uncovered. The average depth of new wells increases year by year. It is now 3,100 feet which means that the wells put down last year represented a total of over 70,000,000 feet of drilling. Should the number drilled in 1937 rise to 29,000 or over the total footage will reach or exceed 90,000,000 feet. The drill pipe and casing required would each extend three-quarters of the way around the globe. The power expended, the machinery needed and the amount of accessory equipment employed may be left to the imagination. It involves a huge annual expenditure, employs an army of highly paid workers and is in every respect one of the big businesses of the country—all to keep the wheels of modern industry revolving without ceasing.

While the cost of drilling a well may vary anywhere from $2,500 to $250,000 it is a fair estimate that $750,000,000 will be spent in exploration and drilling in the United States during 1937 and the cost may run considerably above that figure. While some part of this vast sum may be wasted or, let us say, unwisely invested, a study of past records indicates that it is necessary to conduct a continuous and intensive campaign of exploration and drilling in order to supply the 1,250,000,000 bbl. required for the annual use of the American people and to prevent encroachment upon reserves which although large are none too great to insure the industry's future.

STRAIGHTENING OUT CROOKED "BORROWINGS"

By Elton Sterrett

In an oil field where one company may measure its gathering lines by the hundreds of miles, where daily production approaches the half-million barrel mark, and where a man may drive from dawn to dark without completing the circuit of the terrain under drill, it is inevitable that there be a certain amount of "borrowing" by the less lawful element, all without the knowledge or permission of the "lender" who, in most instances, is a major company and regarded by the purloiner as being more able to stand the loss than would be a neighboring shoe-string operator—and much less likely to go to court or call in the sheriff when or if the trickery should come to light.

Early in the development of the East Texas field every kind of machinery and equipment used in drilling, producing or pipelining was in such demand that premiums grossly disproportionate to the original cost were cheerfully paid to obtain immediate delivery, and the man whose credit was shaky had to struggle along with what reconditioned material he could wangle from second-hand dealers or, lacking that source, had to fall back upon sharp practice to grab what he needed and trust to luck and the future to pay out.

The Case of the Missing Casing

His lease flanked by two major companies, one small producer—who may without embarrassment or direct identification be called Mr. Bright—found himself forced to rush to completion not two, but six offset wells. This was in the days when an East Texas well flowed thousands of barrels where proration now allows it to dribble one percent as much. Fortunately situated on a railroad traversing the field, the producer hastily threw together a loading rack and through it was able to ship the total output from the one well in production on his lease. But drilling costs ate so greedily into his resources that he was unable to outbid others and contract for the casing which, within a very few days at most, must be secured or delay completion and possibly lose production which, if obtained, might see him through his troubles.

From one dealer to another Bright went, futilely offering oil bonuses for casing when others were laying down cold cash, and ever lagging farther and farther behind on his payrolls and material bills. Finally, when he was about ready to throw up the sponge and accept a nominal offer for his holdings, he looked up from his desk in the little office at the end of the loading rack to recognize the gang-pusher from one of the abutting major leases. The man wanted to borrow the telephone, as their own line had been put out of commission.

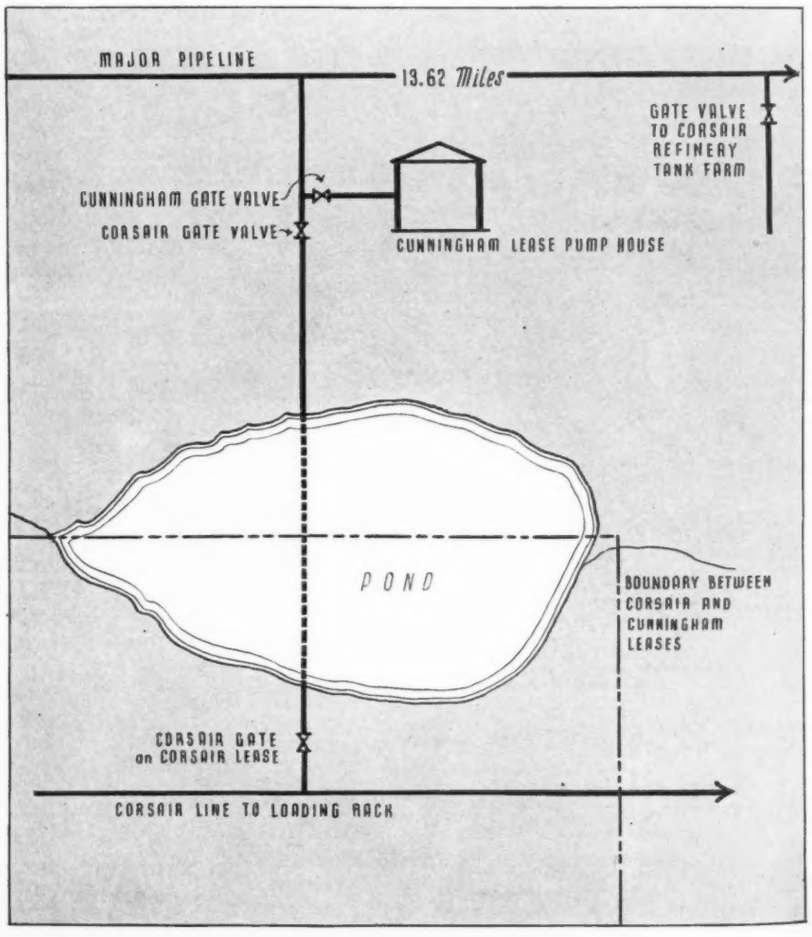
Bright listened, and a possible escape from his dilemma began to grow in his mind. Forthwith he haunted the Longview junction railroad yards and late the second day learned what he sought. Just before sundown the following afternoon a switch engine picked up the four cars from which casing had been unloaded and trucked to the major company's lease; and, when the empties had been kicked temporarily onto the main line, it shoved in another four cars, also racked high with seven-inch casing.

Hardly had dusk settled before two crawler cranes trundled up, a gang of men appeared, and work of unloading began. By daylight all the cars were emptied, and the loading rack man was down at Willow Springs with all Bright's remaining ready cash in his hand. Evidently he was successful, for scarcely any time elapsed before the switch engine nosed in on the loading rack siding, dragged out not only the tank cars containing the night's production, but also removed the empty gondolas in which the casing had been shipped.

It was a full week, in the mad scramble for production, before the major company missed that particular four carloads of casing, and another three days before it was discovered that not one four-carload lot of casing, but two similar shipments, had been spotted on Bright's siding after transfer from their original destination at Willow Springs. In each instance, so the local freight office insisted, the change in destination had been authorized over the telephone by some one stating himself to be the major company's representative and the additional shunting charge had been O.K.'d and, in both cases, paid by the major company.

Checking of materials visible on Bright's lease by men from the major company and the railroad failed to find even one joint of the make of casing shown on the bills of lading; though it was impossible, of course, to peer down the two offset wells of Bright's which had recently been hurried to comple-

Sketch of Corsair and Cunningham leases showing tie-in which borrowed a whole pipeline.



tion—and which, strange to say, instead of further crimping his resources, had lifted his financial burden sufficiently so that all equipment needed for further drilling on his lease was procurable with cash.

Something over six months later Bright dropped in at the home office of the major company, obtained an interview with the operating vice president, introduced himself, and tendered a cashier's check.

The executive fingered the blue paper, handed it back.

"This apparently belongs to our auditing department," he demurred, "but if you'll give me the proper account, I can have it forwarded for you."

Bright smiled, the grin of a man whose worries all lie behind him.

"I tried that, and they insisted there was no account on their books to which it was applicable. You see, some months ago the railroad erroneously set off on my loading rack switch a shipment of seven-inch casing from the Bayou State Supply Company which must have been yours instead of mine, although I also had the amount delivered on order. Somehow my gang got hold of the casing and borrowed it for use in two wells they were just completing for me."

A Five-ton Ditcher Goes A.W.O.L.

Trucks, trailers and other mobile equipment frequently went astray for days at a time, quite often with their official drivers behind the wheel, earning large "bonuses" for the men who thus borrowed them from their rightful owners. The rush over, it was easy enough to report back to the original job with a specious story of having been bogged down in the Sabine river bottoms; or, if hauling in interstate traffic, with a harrowing tale of unjustifiable incarceration by some local "Law" with the consequent tying up on the equipment until the driver could summon aid and effect his release.

One company, pushing its big crawler-type ditcher 24 hours of each day in an attempt to keep field gathering line construction abreast of drilling and completion schedules, had the misfortune to have the ignition on the machine break down just as the trench reached a main highway crossing. Occurring just at shift-time, with no prospect of the machine being again put into service before repairs could be secured, both the day driver and his relief piled into the service pick-up truck, took the damaged parts, and headed for repairs.

What with road delays and the job of locating the key service man in Dallas after working hours, it was within an hour of daylight before the two men returned to the spot where their ditch ended against the highway on one side, and where a line of stakes stretched away on the other for its continuation.

There was no mistaking the trench, but no

Muddy water covers the unauthorized toggle which ties in an additional well and gets its free pumping.

ditcher was in sight, nor could the car's horn summon the two helpers who had been left with the machine when the engineers drove away.

Somewhat surprised that the company should remove the disabled ditcher without either leaving some message or notifying them where to report, both engineers, too dead tired from the night's hard drive to investigate further, drove to their lodgings and slept the clock around before reporting to the field office.

When they did arrive, it was to be summarily fired. Explanations did not explain. To their protestations that it had been necessary to go as far afield as Dallas to secure the needed repairs there came the reiterated: "Oh, yeah? Then how do you explain the fact that our ditcher was heard rumbling down the road under its own power not half a mile from our right-of-way around nine o'clock last night?"

Finally the day engineer managed to get enough of a hearing to get action on his request that they be confronted by Hoyt and Burton, the two helpers who had been left with the ditcher, and who, he insisted, could prove that they had removed the magneto and driven away with it.

Neither Hoyt nor Burton was with any of the gangs on the job, nor could either be located at the boarding place. Finally there came an appeal from the pair, held in jail at Kilgore on a drunk and disorderly charge. Bailed free and brought to the office, it appeared from their story that they had been huddled beside their little fire on the bank of the road in front of the disabled ditcher when a Model T had driven up and one of the three men in it had asked if they needed help.

In spite of their statement that there was nothing that could be done, the same man had gotten from his car and had made a careful examination of the tractor engine. Then he had produced a pocket flask and passed it around. The two watchmen had been cold, and each admitted having taken a gurgle or two from the stranger's bottle. Then, somehow, they had become part of the flivver's cargo, had wound up in Kilgore and later had been impounded by the officers there following a free-for-all fight which, in Hoyt's hazy memory, seemed to have been deliberately provoked by the friendly flivver passenger—the driver of the old car and his other companion having disappeared earlier in the evening.

It was a year later that the day engineer, who had devoted his spare time—from a job with another company—in tracing down one ditcher after another, ran across one far down in the Overton end of the field which somehow seemed even more familiar than others bearing the same manufacturer's name plate. Borrowing a hint from what he felt sure had been an original and ingenious case of hijacking he, too, used a bottle to become better acquainted with the men running the machine. There were three of them, two brothers and a brother-in-law, composing a partnership which contracted for and did the ditch-digging jobs for smaller companies without mechanical equipment, which otherwise would have had to trench their lines by hand.

At last the youngest partner, heedlessly answering a query as to how a man might get a start in such a business, let slip the very information the engineer sought.

"That's dead easy," he chuckled. "Just keep your eye peeled and maybe you'll do like we did. We found our start. Some dumb cluck of an engineer had tied up his ditcher by taking the magneto 'way down to Dallas for repairs, when there was a fleet o' 'Bulldog' trucks at that teaming contractor's not half-a-mile down the road from where he broke down. Maybe he didn't know a magneto from a Bulldog would fit his ditcher engine. We did, and after getting the two watchmen tight it was no job at all to hook up a mag we borrowed from one of the trucks, drive the machine down the road to where a steep bank let us get it aboard a truck, and then it was easy to slip it down here to this end of the field and put it to work."

The Kidnapped Ditch

With landowners in the play getting rich overnight as the gigantic field spread to unforeseen limits, the East Texas farmers lying outside the lucky area could do little but stand by and envy their more favored neighbors. Only in instances where a pipeline right-of-way traversed their lands could any of the freely flowing petroleum dollars be wrung from their soil, and where the landowner was fortunate enough to hold acreage lying athwart the natural course of pipelines from field to refineries or markets, the shrewdness of the native trader sometimes brought in high returns.

One farmer, wearied of long and poorly paid hours in the furrow, had in 1928 set out most of his land in peach trees, having in 1931 a promising young orchard solidly blanketing the land lying alike between one producer and his main line pumping station and intersecting the survey of a second pipeline gathering system main to its tank farm.

Since a gathering line does not of itself come under the head of a public utility, as does a main line pipe which ranks as a common carrier and as such has recourse to the law and condemnation proceedings to limit the landowner's demands, the two companies were forced to haggle with the orchardist for right-of-way through his trees.

Finally one of the companies bid in the right to cut across the barrier plot, and rushed a gang of men and machines into the place to get that portion of the line laid and under ground before any further delays could intervene. Work on both sides of the orchard was suspended to crowd this disputed section in, and the requisite amount of four-inch pipe trucked in and strung along the ditch.

Two hours before actual pipe-laying was scheduled to be begun the company, forecasting increased production from its properties in that section of the pool, decided to lay six-inch pipe to its main line station instead of the four already on hand.

There ensued a three-day delay while the pipe was located, brought into East Texas and trucked to the gap in the fence through which the ditching gang had entered the orchard. Much to the surprise of the truckers and the pipelayers' foreman, they were challenged by the orchardist and his son, both flourishing 12-gauge shotguns, and luridly warning off trespassers.

"There ain't goin-a be no other ditch cut through my land!" repeated the owner when the foreman attempted to parley with him, and when the man insisted that his crew had but come to lay pipe in the trench already prepared by those same men, the farmer finally, to end argument, admitted the foreman that he might point out the ditch in which he proposed to lay the pipe on the waiting trucks.

There was no ditch. The four-inch pipe they had strung through the orchard still lay where it had been dragged by the tractor, but the trench he had seen completed only a scant 72 hours earlier was again filled, a regular ridge of earth cutting across the orchard to continue beyond both boundary fences in unbroken regularity.

Corsair's deadheading hook-up. Over valve pumping, the other the Corsair lin[e] wheel. Water lines show above [in]

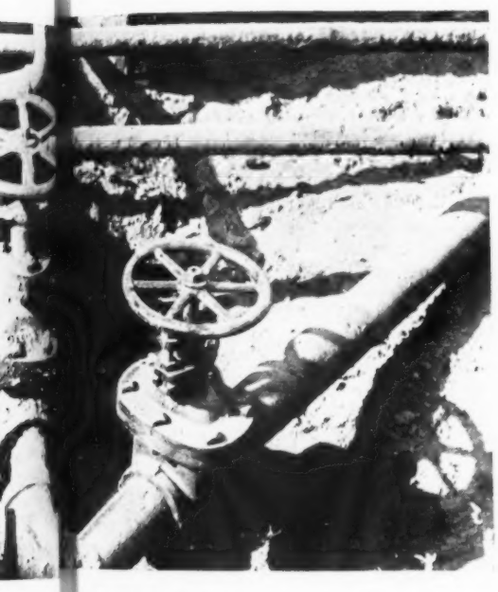
Leaving the trucks and their lading, the foreman sought out his superintendent and with him traced out the mound in both directions. One end tied in with another company's gathering system, the other continued on, with crow-flight directness, for the same company's tank farm. Interrogated, the farm boss knew—or admitted—nothing of the manner in which their line had crossed the orchard.

It was not until after proration became effective, and it was frequently mutually advantageous for two companies to trade production in widely separated sections of the field, that the pipeline superintendent had occasion to become friendly with the tank farm man and won from him the admission that in the rush to get lines laid and

connections established their gang "luckily discovered an abandoned ditch, full of water, which happened to parallel their projected right-of-way through an orchard. Naturally, in an effort to cut every possible corner, the men had drained it and laid their line in this trench, and had of course backfilled it for the protection of their own pipe."

Not that he hoped to be able to do anything constructive about the high-handed "borrowing" of the ditch so long after the fact, but more to verify his own ideas and recollections, the pipeline man checked with the weather office and corroborated his memory—there had been no rain during the three days elapsing between his men's having opened the trench and the discovery that it held another's pipeline.

Still seeking further verification, he took his gang-pusher and a couple of men to carry two test holes down to the interloping four-inch line. The pipe rested on rough, unconsolidated earth clods, with ample voids still existing directly below the metal—a good twelve months after the line had been laid. Had the line been laid in a flooded trench through the soil of the orchard site, all clods would have been reduced to a semi-fluid loblolly, and the lower half of the pipe's surface would have been completely cradled by it as it was lowered into place.



...ook-up. ...valve controls Cunningham lease ...Corsair Li... ...ving been buried without hand ...w above fo... ...inch pirate line.

A Racket in "Used" Tools

Frequently strung out over two or three miles of line at a time, reconditioning gangs absorb an astonishing stock of such tools as shovels, tongs, hammers and wrenches during a year. One pipeline gang foreman admits having bought "not less than 150 shovels" for the needs of a gang averaging ten men, including truck driver and water-boy, during a calendar year—and his needs were not far enough from the average to call for reprimand or even investigation from the man higher up who must sign the tool requisitions.

Some small percent of this loss occurs through bona-fide borrowings, where a tool is borrowed by a man on the gang to do work around his home during hours or days off. Such a tool, once acquired, almost never finds its way back to the gang again unless it becomes broken or damaged beyond further use by its borrower. Occasionally, too, a truck carrying tools for one pipeline gang will break down and leave one group of men without tools when another company's gang may be near, and fully equipped. Tools borrowed in such a case are almost invariably returned, or if damaged while in the hands of the borrower, are replaced with new.

Most of the loss of these easily portable and equally as easily disposed of hand tools is caused by the activities of men who make a business of following pipeline maintenance men over their field work, spotting tools left by careless workmen, or even aiding in the disappearance of equipment by throwing it behind convenient undergrowth if opportunity permit; returning later to collect the spoils and dispose of them, at cut rates, to other users in distant portions of the field or, now that Rodessa and Talco fields are so active, trucking their loot to one of these fields and there selling it.

A "Neighborly" Separator

On many of the larger leases, considerable time and effort was spent in centralizing equipment and so scheduling flows from the various wells that such accessories as separators might be operated as nearly as possible on a full 24-hour service. Especially where the leases were tied in to one of the natural gasoline plants processing the gas produced from the wells with the oil—or, more correctly, the gas which flowed the crude—was this ideal striven for, as a steady flow of gas into the suction main greatly simplified the operation of the compressor system.

Wherever possible one large separator was used, with manifolds connecting in the various wells so that as one was taken off flow as its prorated amount was run another might be turned through the device and not only the wages of several operators saved, but also the task of maintaining adequate supervision cut to a minimum.

Quite by accident, it chanced that the switcher on one such lease had two near kinsmen owning a small four-well independent lease abutting a portion of the larger tract on which the switcher was responsible for well output. Since the kin also sold their oil to the big company across the fence, it was only natural that their tankage should be erected close to the edge of the buyer's property; it was equally a matter of course that the natural gasoline company tied their relatively small gas line, through adequate meter, into the large line carrying gas from the big lease.

Apparently there was nothing out of the way about the situation, but it was not until more than five years had elapsed that the major company had occasion to complete the drilling program on this particular lease, and in so doing planned to utilize two of the three sets of extra manifold valves provided against this contingency late in 1931. Much to the astonishment of the gang-pusher and, when summoned, the district foreman, the two manifold units, supposedly blanked off with bull plugs, were found to be connected and the valves controlling them showing all signs of frequent use.

Tracing of the unauthorized lines led directly to the lease across the fence, and it became plain that the switcher had been flowing the wells of his kin as well as those he was paid to run, and that the one separator had been used for both sets of wells. The small separator connected on the lesser lease was found to be an inoperative shell only, with flow passing directly through it en route to the working unit on the adjoining lease.

Uncovering of the hook-up provided an explanation of how it was that four wells on the one lease had consistently delivered gas into the suction main that metered right up to the maximum permitted under proration limitations, while the score and more of wells belonging to the major company had consistently averaged below that figure, despite the fact that the leases were adjoining and the flow in both instances ostensibly held to the point where the only gas liberated was that dissolved in the oil at bottom-hole pressure.

The former switcher, after attempting to get on with his kin, is now on relief.

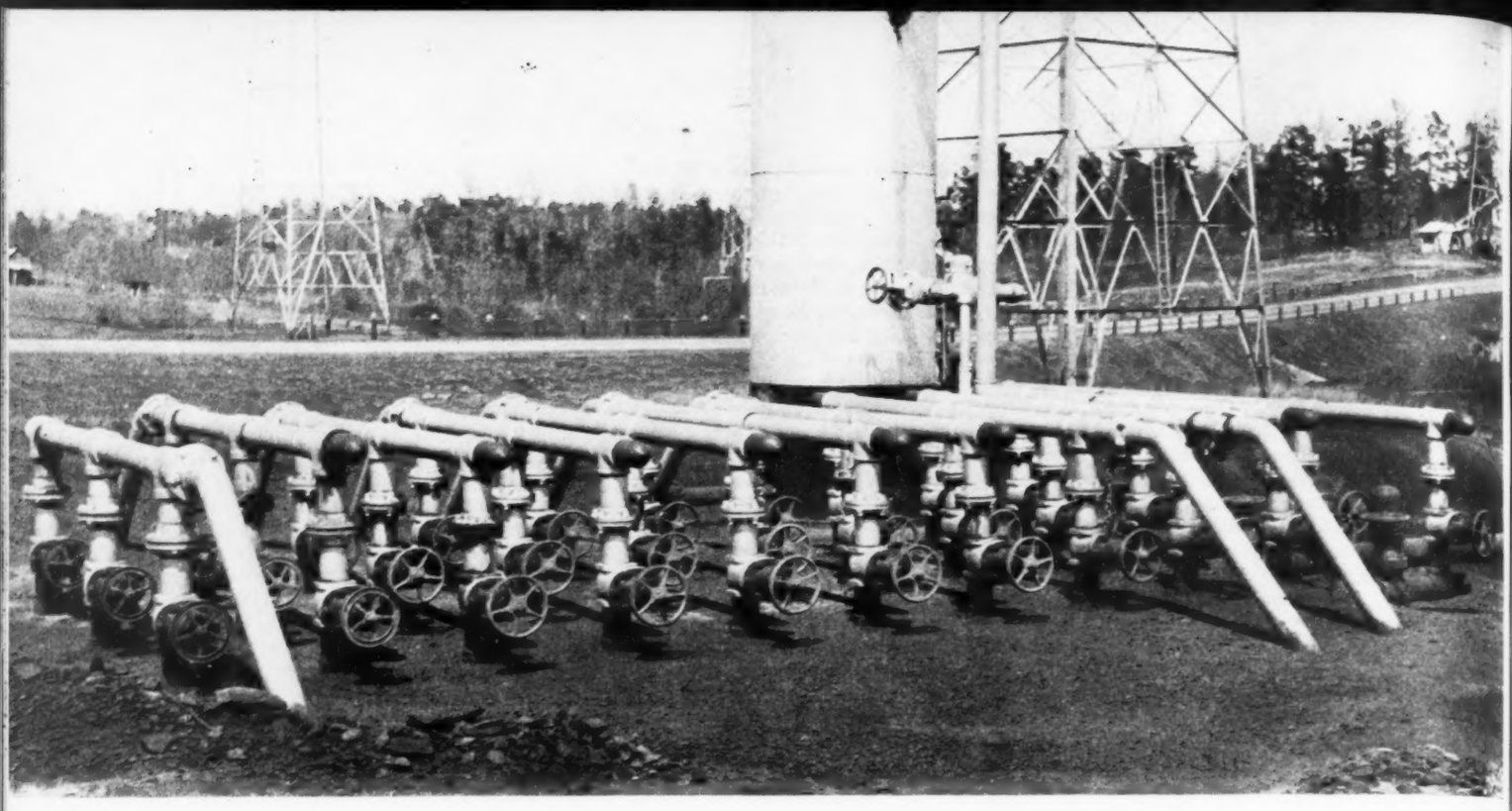
One Good Pull Deserves Another

Central powers, back-side hook-ups and other devices link together the pumping mechanisms of many wells in that section of the field where production is, as operators put it, "on the beam." These well drives, like nearly every other type of oil field equipment, are sometimes asked to lend a neighborly or helping hand, and, unless the operator happens to be of an engineering or analytical turn of mind, the excessive power output demanded of his prime mover goes unnoted and unprobed.

As with the community separator cited, practically all these helping-hand hook-ups of unauthorized wells are maintained through the connivance of the man in charge of production on the lease whereon the pumping power or other driving unit is located.

There is the instance of one lease where the central power was pumping—officially—eleven wells, but where it was quickly possible, simply by threading a cable through a barbed wire fence and hooking it to the swing post in a certain pull rod string, to tie in four additional wells. That this load seriously unbalanced the carefully worked out distribution of stress around the power and imposed excessive bearing loads with consequent wear on the overloaded section was ignored by the switcher manipulating the power-stealing device.

Repeated pull-rod failures—all concentrated within one section of the power hook-up—failed to occasion alarm or initiate investigation by the management. The easiest way out—that of replacing the size specified for the job with larger rods—was taken.



For years such a separator hook-up not only carried its own lease production but also handled—gratis—the wells of a neighbor.

Not until an engineer from the supply company furnishing the pull rods was interested enough to saw off and carry away with him some half dozen three-foot lengths of rods terminating at the breaks was any suspicion directed toward the actual load being borne by the troublesome sector.

As reported by the testing laboratory to which the failed rod sections were referred, all breaks were due directly to overstressing in tension—the rods were actually pulled in two. This overloading was so severe that similar breaks in the testing machine in the steel adjoining the original fractures, though the entire length of rod had more than likely been stressed beyond its elastic limit, showed that loads in excess of 400 percent of the maximum computed for or specified in the original specifications must have been imposed.

Acting on the tip tendered by the rod engineer, investigation quickly brought to light the cable, and cost the switcher his job. Further probing showed that the man had been receiving a mere $5.00 per week for his services in stealing the power required for pumping the four wells on the adjoining lease.

Another instance of borrowed power is where the lone well on a three-acre lease is pumped—quite without authorization—by the same engine which drives the pumps on the three wells on a line with the one "thumbing" its way. The engine is set, as customary under the center derrick of the three, the wells on either side of it being pumped from the back-side crank. The pull rod line to one of these wells passes beneath a road, being slung from a pair of pivoted hold-down arms and working within a section of eight-inch pipe buried below the road level.

Somehow, this depressed section of pipe seems always to be filled with water, even during the more or less extended dry seasons normal to the portion of the state where the wells are located. Not only is the entire portion of the pull-rod below the roadway submerged, but also a line of six-inch pipe which likewise penetrates the roadway fill at the farther end—with reference to the power unit—and which parallels the rod for the short distance it would be visible were the water drained away.

Inside this pipe is carried a rod which extends right on past the well openly pumped and then, working through a right-angle turn, also takes the pumping duty for the lone well. As the jack for this well is set at ninety degrees to the ones on the string of three wells, and the pull rod for the single well aims toward and presumedly passes under the railroad directly in line with the offset well across the right-of-way, it is apparently nobody's business to ferret out how the well is actually pumped, or why the water faucet in the front yard of the man living just two doors away from the road crossing is always allowed to flow enough to maintain the puddle which, due to the constant agitation of the pull-rod string, is muddy.

Yet the double load is audibly evident to any one who troubles to pause by either hold-down and listen to the double reversal of load and to note that one half of the thumps are slightly behind the others, legitimate offspring of the load on the jack pumping the well apparently furnishing the sole and entire load. A still more remarkable concidence, for any one interested, is the fact that the man with the leaky faucet happens to be the owner of the one-well lease.

Deadhead Barrels Ride the Pipeline

Even pipelines are sometimes used through long periods of time without the knowledge or permission of their rightful users. Numerous instances of this abuse came to light during the drive to eliminate illegal by-passes as State authorities strove to halt the flood of "hot" oil being surreptitiously produced and run to market in the early days of proration enforcement. That some of these also aided in the theft of oil is evident from an earlier article* in which were described certain cases where legitimate connections were altered or rendered inoperative by oil pirates.

There is at least one flagrant case in which a producing and refining company used a thirteen mile stretch of pipeline belonging to another concern over a period of five years—and probably would still be so doing if a pumper hadn't chanced to snatch a forbidden forty winks out behind his lease unit and wakened to sense the stoppage of his unit, but to find the gauge on his pump discharge unexpectedly showing a steady pressure of almost 400 pounds to the square inch when he was positive his was supposed to be the only unit pumping into that particular section of the field lines at that time.

The company, to be referred to under the slightly disguised name of the Corsair Oil and Refining Company, owned and operated an isolated lease across the Sabine river and nearly fourteen miles away from its small refinery. Production from this group of wells was supposedly run into tank cars on its loading rack and handled via rail to the refinery spur; though that, of course, was no-

* "Probing Pipeline Pilferage," March, 1937, WORLD PETROLEUM.

body's business but Corsair Oil and Refining's.

Adjoining the Corsair lease was a major company's Cunningham lease, tied into its main field gathering line trunk with a small gasoline engine powered pumping unit to move the oil. As luck would have it, this trunk line paralleled the railroad and passed just outside the yard fence of the Corsair refinery. After a series of negotiations, the major agreed to tie its gathering line in to the refinery so as to be able to exchange production with another of the Corsair's leases, this exchange repayment to be made through the major's trunk line and into the refinery tanks through the short branch line.

As the small lease forming the basis of the exchange agreement had only two wells on it, and as proration had cut the daily allowable on them to less than 45 barrels per day joint production, it was the major company's practice to accept the Corsair runs as the lease tanks filled, and to replace it at the refinery in lots of 1,500 barrels each. This meant that the gate on the branch into the Corsair refinery tank farm was officially unsealed and opened on an average of only once per month.

A member of the Corsair organization happened to be on the Cunningham lease when the field pump station was being equipped with a flowing water cooling system to replace the enclosed tank formerly used, and from what he saw on his daylight visit came an idea which led to another, shortly after darkness had halted the other pipeline gang's activity.

The pair of two-inch lines carrying cooling water to the pumping engine were quickly uncovered by the night crew and the trench deepened another two feet. Then, pulling the bull plug originally installed in one end of the Tee to provide access for possible cleaning, a four-inch line was laid below the two water carrying pipes, carried up to a nipple replacing the bull plug, and tied in there with a gate valve. Before the trench was again backfilled, the valve wheel on this gate was removed, and the entire addition to the oil line hidden not only to sight from above ground but also—by the superposed water lines—against detection by any but the most careful survey with an electrical pipeline finder.

Carried across the pond and worked well into the muck forming its bottom, the new four-inch line tied in to the line already installed by Corsair from their lease battery to the loading rack. A second four-inch gate valve was incorporated in the branch, close up against the Tee permitting the new line.

Since the gate on the stub from the major's line into the refinery was used only once a month, it was normally sealed in the closed position, the seal strap being passed around a spoke in the wheel and also encircling one of the studs in the gate stem stuffing box assembly.

With the new hook-up, it was easy enough to learn when the major's field line was not in use—the rhythmic click-thump of the plunger pumps telegraphed the fact of pumping throughout the system—and then to start up the pump at the Corsair lease, leaving the loading rack valves closed, opening that on the branch to the Cunningham lease line, slipping out the stuffing box stud which held the seal strap so as to wheel open the gate it supposedly guarded, replacing the stud and pumping merrily through the major's line until the lease tanks were empty.

The pumping chore completed, the stuffing box stud was again removed, seal strap once more threaded into place, and the line closed again to allow normal—major—operation until further need arose.

The branch gate adjoining the Tee in the Cunningham lease was originally installed with the idea that it could be normally left closed, and opened with a socket bar without noticeably marring the ground surface whenever Corsair wished to "borrow" the trunk line, but as the scheme proved so successful on first trial, plans were perfected to ship all but nominal amounts of crude from its lease in that way.

By controlling flow with the valve on its own property the concealed gate on the Cunningham lease was just left open, and no actual trespass committed when a run was to be made. Centrifugal pumps were used on the Corsair lease line, so that even if they were operating, the first thump of a plunger pump on any of the major's leases would instantly telegraph its being placed into service, and thus warn Corsair to suspend its oil movement until the line was again clear.

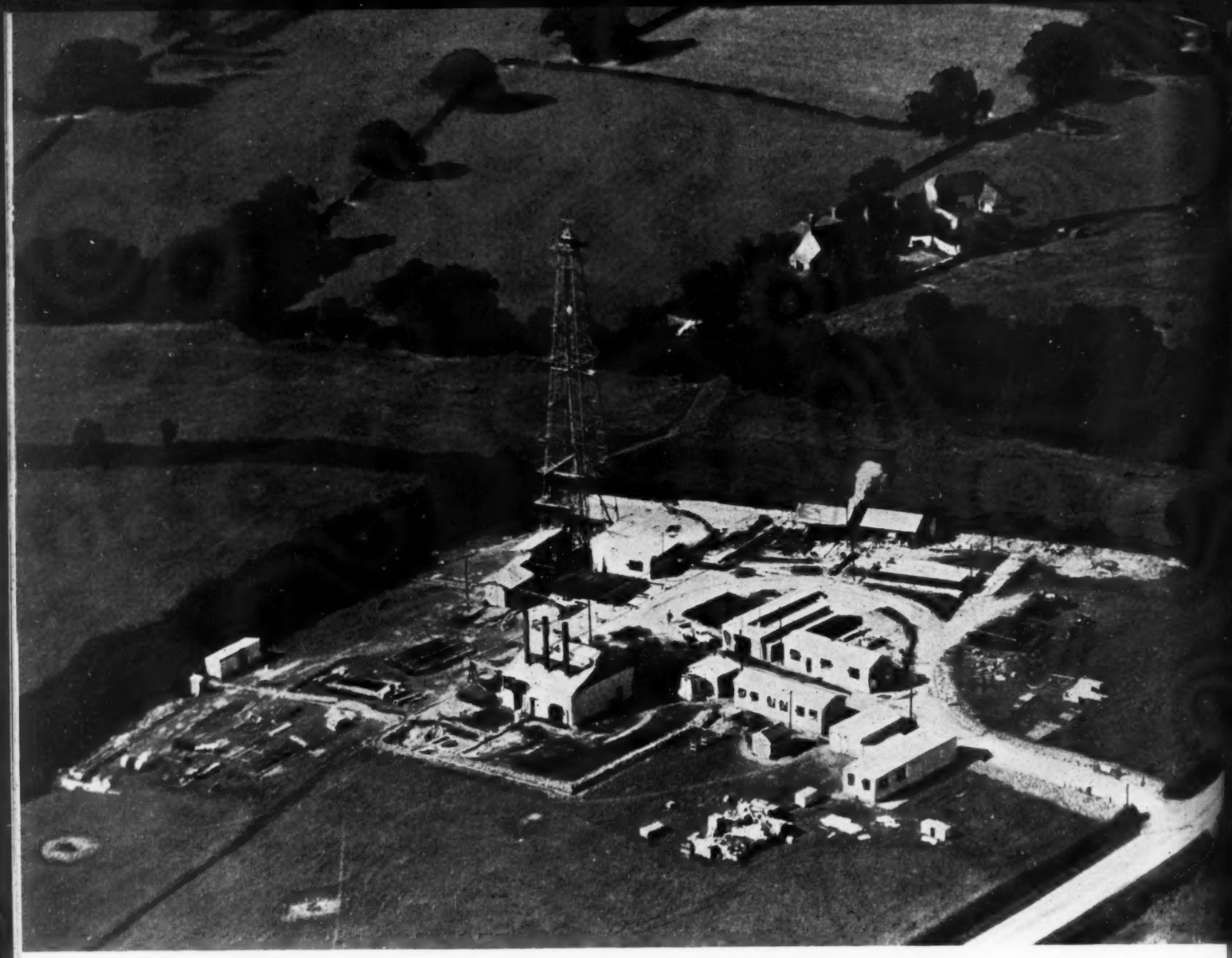
Since the allowable production of the Corsair lease was 3,000 barrels per month, their borrowing of the other company's trunk line saved them the usual field charge of five cents per barrel for gathering, which—disregarding other savings—amounted to $150 per month and which if computed as rail freight, would have run several times that figure.

When, following discovery of Corsair's tie-in after the surprised switcher reported the freak pressure registered on his gauge, the whole scheme was apparent, did the major tear up the Corsair's line and attempt to collect damages or exact penalty for unauthorized use of its line? Instead, the gate originally installed by Corsair at the Cunningham lease Tee was again put into service, and the major acts as common carrier for all Corsair's run to its refinery—allowing Corsair, for the usual field pumping charge, to use its own power to force its own oil into the major's line and so run into its tanks a like amount of crude—the entire operation being watched by gaugers representing both firms, and payments for services rendered coming through promptly on the tenth following the month of service.

Curtailment of losses such as those cited is possible, at the cost of adequate supervision following a survey of the possible avenues of loss; for just as long as materials and equipment are carelessly watched and lavishly used, just so long will there be those who will be prompt to seize upon such laxness and profit thereby raising the cost of oil production and adding in this way another of the multitudinous tolls which knavery and crime extract from business and prosperity.

Big and heavy as it is such a ditcher was borrowed and operated without detection for over a year within ten miles of its snatching.

© The Buckeye Traction Ditcher Co.



Henfield No. 1—second test of Anglo-Iranian—which reached 5,105 ft.

BRITISH DRILLING CAMPAIGN

American and English Companies Friendly Rivals

No Oil but Considerable Geological Knowledge Has Been Obtained from Anglo-Iranian's Test Wells—Search Spurred on by Entry of Other Firms

BRITAIN'S SEARCH for indigenous oil production is now coming into full stride, some 11,350 square miles are under prospecting licence in England, Scotland and Wales out of a possible 96,211 square miles, or 11.7 percent of the island's total area.

The new drilling regulations—the Petroleum (Production) Act, 1934—were promulgated in May, 1935, with the first grant of prospecting licences being made to D'Arcy Exploration Company, Ltd., subsidiary of the government-controlled Anglo-Iranian Oil Company, Ltd., in the latter part of the year. Subsequent licences granted to this company have brought the area in its possession up to 9,233 square miles, covering 19 counties in England and two in Scotland. Having entered the field nine or ten months in advance of any other concern Anglo-Iranian has naturally made the greatest progress and has completed two wells, both dry holes.

The Portsdown test, near the Portsmouth naval base, was commenced March, 1936, and was continued to February of this year. The second test was spudded-in during May, 1936, at Henfield, also in the south of Eng-

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land, and was completed last March. Inasmuch as both of these wells were penetrating through entirely unknown strata utmost care was taken to ensure that full geological information was obtained by frequent coring.

These wells set an all-time record for depth in Britain; Portsdown No. 1 reached a final depth of 6,556 ft. and Henfield No. 1 went down to 5,105 ft., compared with the previous record depth of 4,245 ft. in the Apedale No. 2 well (also a duster) drilled in the 1918–22 campaign by S. Pearson & Sons, Ltd. on behalf of the Mineral Oil Production Department of the Ministry of Munitions, under the Defence of the Realm Act.

Drilling in the Portsdown well was commenced with a 23-in. rock bit which was used to a depth of 1,110 ft., at which depth the 18-in. collar casing was set and cemented. Cementing was by the tubing method and nine tons of cement were used.

When pulling out from 250 ft. depth the bit stuck at 203 ft. and usual methods of release failed. It was then decided to try the effect of a steam jet playing around the reamers and the bit. Three-inch cement tubing with a three-quarter-inch side jet was run and some time after turning on the steam the bit began to settle down under the weight of the column and the tools were recovered.

From 1,110 ft. drilling was continued with 17½-in. bits to 2,320 ft., and 15-in. 71-lb. inserted joint casing was cemented by the plug method at 2,311 ft., using 24¼ tons of cement. The diameter of the hole from this point to 3,655 ft. was 14⅛-in., then 10⅝-in. to 5,529 ft., and 7¾-in. to bottom. Careful weight control resulted in a straight hole to 5,500 ft.

Although clays were encountered in which drag bits would be expected to drill with ease, it was only with rock bits that reasonable progress could be made. In the first 5,840 ft. the footage drilled by various types were: rock bits, 2,493 ft.; core bits, 1,394 ft.; drag bits, 1,108 ft.; and other bits, 845 ft.

When drilling was stopped in the Portsdown well a Schlumberger electric core was made over the uncased portion of the hole, particularly in order to obtain detailed records of porosities before it was finally plugged.

Results obtained from these wells were very disappointing, although it was known all along that there was a strong element of chance due to the lack of geological knowledge of the area. Surface evidence in the form of outcrops of suitable sands at some distance had indicated that deep below the overlaying chalk oil might be found under the tectonic conditions which existed there, and when the particular formation was reached by the Portsdown well not only was it much thinner than had been anticipated but the rocks were found to be "as solid as indiarubber," as Sir John Cadman, chairman of the company, put it. The porosity was less than one percent.

There were minor traces of oil during the sinking of these holes, and it is felt that the geological information which has been obtained is in itself of great value in furthering the search, and it is safe to put the extension of Anglo-Iranian's licenced area in that region as due to the knowledge gained of possible oil structures.

Lack of success in its first two tests has not diminished the enthusiasm of the Anglo-Iranian campaign, and perhaps has only served to intensify the search—for there is a certain amount of friendly rivalry between the British company and its two American-controlled competitors. Throughout the drilling of these two wells many surface geological bores were sunk to depths as great as 528 ft. to check the contacts of beds. Likewise the company has conducted considerable seismic and torsion balance work in a number of counties, especially in the central and eastern licenced areas. The result of all this exploratory work has been the selection of a number of future well sites, and rigs are already being assembled for drilling which should soon commence. The sites selected are: at Kingsclere, Hants., to the south of Newbery, Berks.; at Eskdale, near Whitby, Yorks.; at Poxwell, near Weymouth on the south coast; and at Cousland, near Dalkeith, Edinburgh district, Scotland.

The latter site is in close proximity to a comparatively successful well drilled at the village of D'Arcy during the immediate post war campaign of the government. A most interesting feature is that the latest licences granted to Anglo-Iranian cover the important chain of wells sunk for the government in Derbyshire, close to the Hardstoft well, and the oil possibilities of this much-disputed area should at last be settled beyond doubt.

The Duke of Devonshire has a four square mile concession, granted in 1923 under the old war-time regulations of 1918, which includes the Hardstoft No. 1 well, Britain's only producer (357 bbl. in 1935). The oil obtained is of high-quality lubricating stock and, subsequent operations have proved, is a naturally-filtered fissure oil and its source is believed to be deeper and perhaps far away. At that time the Duke was very much interested in proving the nation's petroleum resources and sunk two further wells at Hardstoft, one of which produced fairly strong flows of natural gas, but no oil was obtained. His enthusiasm was dampened and he has never done any further work. It is understood that he will not permit assignment of his licence to any firm willing to undertake drilling there.

Anglo-American Oil Company Ltd., subsidiary of Jersey Standard, and original purchaser of Hardstoft oil, was second to obtain prospecting licences from the government under the new regulations. These were originally for 478 square miles in the south of England, adjacent to those of Anglo-Iranian, but none were granted over Scotland despite the fact that it had been understood that Anglo-American had applied for the D'Arcy well-site.

Some 35 bbl. of highly paraffinous oil had been bailed from this well at a depth of 1,807 to 1,820 ft. in 1922, at the end of the government campaign. No adequate test of the geological structure was made, the horizon was neither acidized nor dynamited, and no attempt was made to drill to the two possible petroliferous horizons at 2,600 and 2,900 ft. respectively, despite recommendations of the deputy director of the Petroleum Research Department.

A licence over the 12 square miles immediately surrounding this well-site was later granted to the Midlothian Petroleum Syndicate, and subsequently was transferred to Anglo-American for development, bringing the latter company's total area up to 490 square miles.

The first six months following grant of licences to Anglo-American in August, 1936, were spent in conducting geological and other exploratory work by the company; shallow bores were sunk with portable rigs for further information and to check on surface conditions. Early this year the firm announced that it had selected a site on the Grove Hill anticline, a mile northeast of Hellingly, just south of Heathfield for its first test well, and erection of rotary equipment capable of 7,500 ft. commenced at once. Official commencement of drilling will take place this June, and it is expected to drill to about 4,000 ft. Coal is used to raise steam for power.

Heathfield is a village already made fa-

© Gaumont British, London

Hardstoft No. 1 has produced oil continuously for over eighteen years.

mous for its flow of inflammable gas which has been used locally for many years, and Anglo-American will core continuously and make formation tests, also bailing tests will be made if necessary to determine the origin of this natural gas. At Pevensey, to the south, is an outcrop of oil sand, while numerous seepages and oil shows have been observed in the neighborhood. Two other areas licenced under the old drilling regulations exist in this district. One is near Heathfield, being one square mile in extent, and belongs to Henry King Hiller. It has never been worked. The other is also small, although somewhat larger than that of Mr. Hiller, and belongs to Kent and Sussex Oilfields, Ltd., formerly operating under the name of N.M.D. Syndicate. Several years ago the N.M.D. drilled two tests at Three Bridges, in the Worth Forest, about 20 miles to the northwest of Heathfield. The first was sunk to but a few hundred feet and abandoned, while the second reached a depth of 1,886 ft. before operations ceased. Several oil shows were reported during drilling, but no conclusive evidence was gained. It is understood that Anglo-American investigated the possibilities of this licence with a view of applying for assignment but were not impressed. Continental interests, said to be the Anton Raky group, are reported to be negotiating for the further testing of this area.

Anglo-American and Anglo-Iranian wisely agreed early in the game to exchange technical information on the results learnt from test wells in the areas each holds under licence, some of which are contiguous. Such pooling of geological knowledge and interpretation avoids unnecessary duplication of efforts.

The next group of licences to be granted under the 1934 Act were in the Midlands, to Steel Bros. & Company, Ltd., covering an area of 350 square miles. This company is managing agent for Indo-Burma Petroleum Company, Ltd., Attock Oil Company, Ltd., and Pynima Development Company, and this interest in British oil search is a fresh enterprise. The initial test will be drilled near the village of Upper Booth, west of Edale railway station in the Edale Valley, and it is hoped to commence in June of this year. A Star percussion rig with a 96-ft. steel derrick is to be used.

The latest development at time of writing has been the official announcement that licences have been granted to Gulf Exploration Company (Great Britain), Ltd., subsidiary of Gulf Oil Corporation, recently formed with a nominal capital of £20,000. These licences cover an area of 1,277 square miles in widely separated areas of England, although most are in the south, and surface geological and geophysical exploration is already commencing.

It is an unfortunate fact that the areas licenced under the 1918 Act are exempt from the 1934 Act, and thus can remain inadequately tested or not developed at all—the bright side of the question is that these licences are in all cases over but minor areas, and are surrounded by licences of the more enterprising companies complying with the new regulations, and there remains little doubt that should petroleum exist in commercial quantities these companies, with their world-wide experience, are sure to find it.

Running in a new section of pipe at Henfield.

DRILL PIPE FAILURES

Due to Faulty Design

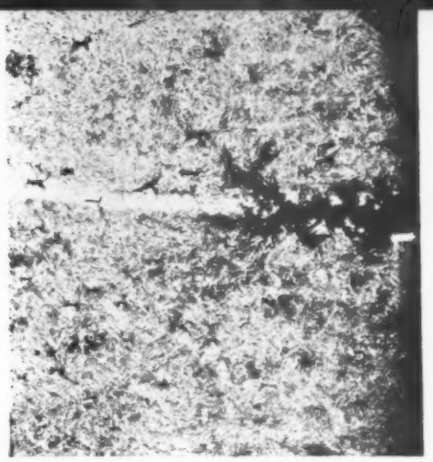
By J. E. Brantly

With Increasing Drilling Depths Necessary to Maintain Reserves Changes in Design and Construction of Drill Pipe Have Become Essential to Economic Exploitation.

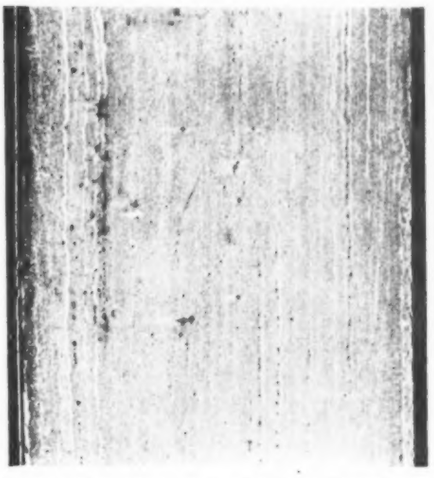
WITHIN the past several years the part of the petroleum industry engaged in the drilling of wells has passed from the development of the shallow, more obvious areas of production into the present fields of moderate depth and now faces the need for exploring the deeper horizons and less obvious structures, in order that the reserve of oil in sight may be held at the largest possible maximum commensurate with the technical and mechanical skill of the oil finders. The penetration of these deeply buried strata involves problems in the drilling operation that are much more complicated and which place a far greater burden upon the presently available equipment than it is capable of withstanding, within sound economic limits. With these requirements for deeper wells, the manufacturers of drilling machinery and tools must develop and perfect equipment that incorporates mechanical improvements capable of discharging the required duties while the operating personnel advances its technique of drilling wells. In addition to these requirements there is the equally pressing need for better tools with which to accomplish their present assignments.

Among those parts of a string of rotary drilling tools that have seen material improvements and need still more, in one way or another, is the drilling shaft or drill pipe. From a beginning of ordinary line pipe, with "V" threads and short couplings, this tool has passed through various stages until it now consists of a kelly or grief stem at the top, drill pipe connected with tool joints next below and finally the drill collar into which the bit is screwed. The original and the present drilling shafts are alike only in that they are tubes fastened together with threaded connections. The kelly and kelly bushings, which take the place of the old drill pipe and grip rings, the heat treated tool joints by means of which the joints or drill pipe are fastened together, the metal or alloy of the tube itself and the heavy drill collars are all improvements on the original and are essential to the nature of the demands now made upon it. Even with these vast improvements the need for more economy in our present operations and the greater depths to be penetrated necessitate drilling shafts, particularly in so far as the pipe itself is concerned, capable of withstanding much greater stresses and labor that are conducive to metal fatigue and failure, than will the present shaft.

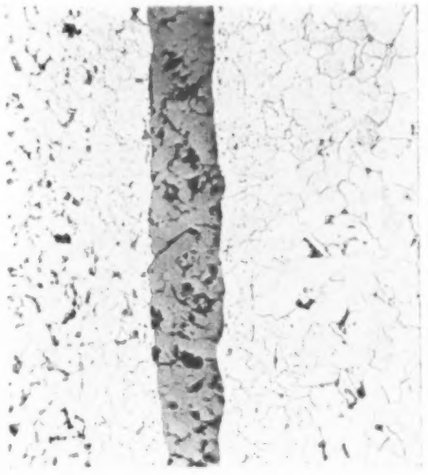
It is estimated that during the year 1936 some 80,000,000 ft. of hole were drilled with rotary tools. It is further estimated that the average string of drill pipe drilled about 80,000 ft. before being "layed down" or junked. This indicates a consumption of 4,000,000 ft. of drill pipe during the year which, at an average cost with unsalvaged tool joints of $2.70 per foot, shows a total cost of $10,800,000.00. It is further roughly estimated that there were, during this period, some six thousand fatigue failures which at an over-all cost of $300.00 each would give an additional drill pipe cost of $1,800,000.00, or a total figure for junked pipe and fishing jobs of $12,600,000.00. This shows an overall cost of approximately 20 cents for each foot of hole drilled or one and one quarter cents per barrel of oil produced, and this includes the vast majority of simple problems. In the more difficult areas these footage costs run to as high as 50 cents and in rare cases $2.00 or more per foot. With the



Phosphorus band in 10-20 casing steel magnified 100 times, showing decomposition at surface, which could occur at root of a thread.



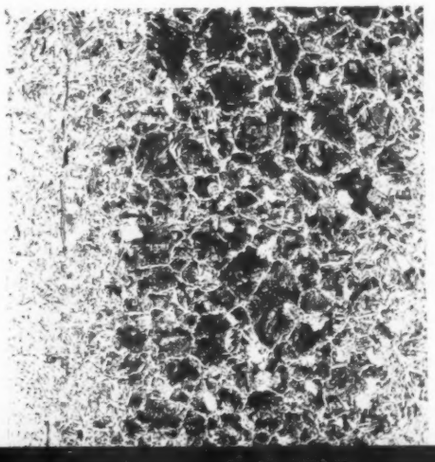
Rolled plate steel, etched to show phosphorus banding distinctly.—Magnification 100 diameters.



Streak of iron oxide resulting when scale is rolled into 10–20 steel during mill working, magnified 100 times. These brittle streaks result in torn and ragged threads.

Left: A high carbon streak in 10–20 steel. In improper heat treating this creates a zone of brittleness and fracture.

Right: Polished section of broken shaft, showing slag inclusions resulting in embrittlement and failure—cold rolled steel magnified 14 diameters.



increase in depths and the consequent greater difficulties in drilling problems it is this latter figure in which we are interested. An intangible cost that may be as important as that of the mechanical failure is that caused by the fear and expectation of pipe failure and the consequent decrease in morale of the drilling crew.

There are certain inherent weaknesses in the drilling shaft, as now constructed, that are in largest part accountable for these failures and their consequent costs. It is toward a discussion of them and suggestions for improvement that this paper is directed.

IMPORTANCE OF THE DRILLING SHAFT

The drilling shaft is by far the most important tool among those which make up a string of rotary drilling equipment, and it limits the work of which the equipment is capable. The most important factor in the operation is the drilling fluid, both in character and quantity. Having a drilling shaft of adequate capacity and the drilling fluid factor in proper value, practically any given problem can be solved. The time required for such accomplishment will then depend upon the other machines and drilling factors involved.

NATURE OF WORK DONE

The bit or cutting tool is attached to the lower extremity of the drilling shaft. At the upper end of this shaft the kelly or grief stem, by means of which the shaft is rotated, is attached. It is this cutting tool that accomplishes the actual displacement of the formation, and it is the drill pipe that must transmit the labor or energy received from the prime mover through the kelly, to the bit on bottom. The rotary table, actuated by its prime mover, tends to rotate at a given speed and at the same time the bit on bottom has a tendency to come to rest, due to the braking action of the formation against and into which it is rotated. Between these two extremes there are various speeds of rotation, instantaneous changes from one to another, stalls and releases, all of which are sources of highly fatiguing stresses that must be absorbed by the drilling shaft. The drill pipe will be rotated in compression if the bit is allowed to carry more weight than that of the mass of the drill collar. This is conducive to metal fatigue in the thin sections of the wall of the pipe, or between rigid and flexible sections. In large size holes there is the tendency toward an universal joint action, which is further fatiguing. Under other circumstances the bit may be rotated through the medium of the drill pipe and drill collars with a maximum of the drill collar weight on bottom. In this case the drill pipe is in tension and in a large or irregular hole will tend to "whip." Further, a combination of bit action on bottom, the nature of the formation and fluid pulsations will cause harmonic vibrations in the tube. These induce fatiguing stresses that are concentrated in planes of sudden change in cross-sectional areas.

The ordinary method of attaching tool joints to drill pipe is by use of the A.P.I. standard drill pipe thread, which is approximately the Whitworth thread, being of the "V" type with rounded root and crest on .017 and .020 radii, respectively. This slightly rounded thread is cut in the ends of the drill pipe, which is normally internally upset. The pipe end of the tool joint is recessed so that it does not come in contact with the metal of the tube and when fully made up onto the tube, leaves from 2 to 6 full or "stand off" threads that are unengaged. The practice of welding these tool joints to the drill pipe has become common in certain areas.

One manufacturer uses drill pipe that is slightly upset externally as well as internally. The upset beyond the thread is machined to a smooth surface and the inside of the recess of the tool joint is finished to a size some .003 of an inch smaller than the companion surface on the drill pipe. The tool joint is heated until it expands several thousandths of an inch and it is then screwed onto the end of the tube by hand. The make up is completed in a pipe machine in the usual manner. Before the tool joint is screwed onto the tube the machined surface on the upset is swabbed with a copper sulphate solution, which deposits a thin film of copper on the surface of the metal. This copper film serves as a lubricant. This so-called shrink fit serves to strengthen and stiffen the wall of the tube in the zone of the offset or unengaged threads. Another manufacturer machines the drill pipe and the tool joint in a similar manner, but uses a slight taper to effect a firm contact rather than the shrink fit. These joints likewise add stiffness and lend material protection to the unengaged thread section. For a time a joint was manufactured that used the principle of the shrink grip entirely for its attachment to the drill pipe. No threads of any kind were employed.

All of the above joints are usually built on internal upset pipe though externally upset, internal flush pipe is likewise used. Another method of attachment to the latter type pipe involves the threading of a working joint into the upset end and flush with it, both outside and inside. Still another builds the tool joint box and pin as an integral part of the pipe.

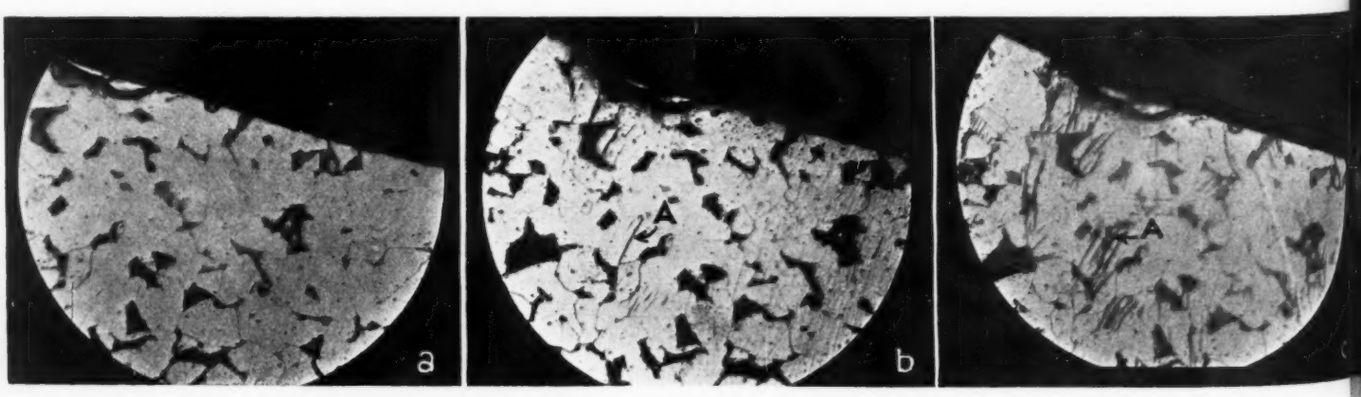
The metal most commonly used in all drill pipe is the so-called grade "D" steel, which has a tensile strength of about 95,000 lbs. and yield point of some 55,000 lbs. per square inch.

TYPES OF FAILURES

There are three primary types of drill pipe failure, two of which are caused solely by metal fatigue and occur as fairly clean breaks either in the root of the first full thread or in the length between the upset ends usually near the lower upset. The third may correctly be called a torque failure or "twist off" which results from the application of a greater torque than the tube is capable of transmitting without rupture. When couplings are used to join two joints of drill pipe in making up doubles, failure frequently occurs as a thread root fatigue breaks in the coupling between the ends of the two tubes.

Tool joint failures are extremely rare at the present time, and when they do occur

Micro-photographs of a piece of steel subjected to progressively greater fatiguing stresses, the first indicates the polished surface before fatigue sets in and the last indicates the definite crack developed.



they are generally in the angle formed by the junction between shoulder and pin.

METHODS AND OBSTACLES

The foregoing paragraphs have as their primary object the setting down of the various designs and principles involved in the joints of a string of drill pipe and is for the purpose of affording concrete examples or statements of the conditions with which we are dealing and which must be overcome in increasing the usefulness of the drilling shaft. Their importance to the industry rests partly in increased efficiency and decreased costs in drilling operations generally, but of greatest ultimate value in placing within practical reach of drilling tools those petroleum deposits which are beyond the ability of present equipment to develop. Assuming that there are substantial petroleum deposits beyond the 10,000 ft. depth, its economic exploitation rests upon a very substantial improvement in the tools with which the driller works, the most important of which is the drilling shaft. It may be properly added that there must likewise be substantial improvement in the methods of using this tool.

It has been stated that there are two principal points of failure: (1) in the root of the thread on the ordinary drill pipe, and (2) in the normal tube generally near the beginning of the upset. The thread failures caused by metal fatigue are much more common than are those in the body of the pipe and they occur regardless of how the pipe may be used. Those failures in the body of the drilling tube that are the result of compressional fatigue, may be avoided by the use of sufficient drill collar mass to permit the drill pipe itself to remain in tension but the failures in the root of the thread can only be eliminated by a change in design. This is accomplished to some extent by the so-called "shrink fit" and taper shoulder joint and by welding the tool joints to the tube; but these do not correct the inherent weakness and therefore it is probable that upon continued use of these new type joints, thread failures will still occur.

"It is a well known fact, verified both by practical experience and by laboratory investigations, that in the construction of power transmitting mechanical appliances abrupt differences in cross section should be avoided, because it is at such places that differences in strain will be most increased. Breaks will occur at these transition points before the strain in the other parts, where the cross section remains uniform, has reached the breaking point. The matter is not so important where the construction is subjected only to a static stress, because when the elastic point is exceeded the part concerned will expand or stretch and thus transmit part of the tension to the adjacent parts. On the other hand, abrupt changes in cross section are especially dangerous in a mechanical appliance that is employed under conditions which affect its resistance to vibrational strains. Since under vibrational conditions there is very little plastic deformation of the most severely affected parts, there is little opportunity for an equalization of the tension by transferring part of the strain to adjacent portions of the mechanism. Consequently, the vibrational resistance of the part as a whole is markedly reduced.

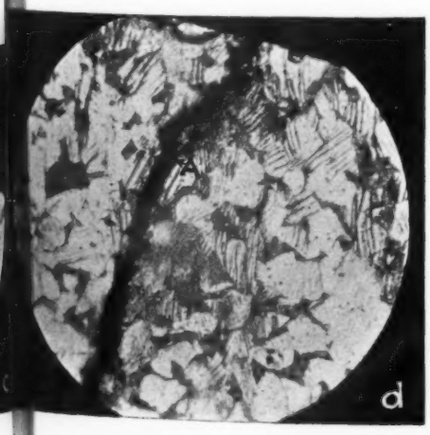
"The changes in cross section need not be very marked to have a large importance. It is known that small scratches, scarcely visible to the eye, may greatly reduce the resistance of a rod to vibration, and may give rise to premature breaks in operation. A realization of the damage that may come from the presence of small scratches occasioned by machining operations has led to the practice of subjecting machined surfaces to rolling pressures heavy enough to fill the scratches by plastic flow of the metal, thus restoring uniformity of cross section.

"Among machine parts that exhibit the most abrupt changes in cross section are threaded rods and tubes, and it is notorious that it is in the threaded parts that breaks most frequently occur when rods and pipes are subjected to vibrational strains. The threaded parts are weakened not only by the presence of the threads, but also by the form to which the threads have been cut. Where the thread grooves have a V-form, that is, where the sides meet to form an angle and thus present an abrupt change in cross section, the most favorable condition is provided for the development of the most severe vibrational strains.

"These considerations point to the desirability of cutting the threads of pipe so that they will have rounded instead of V-shaped bottoms. It is important that the thread-cutting machine not only produce the right form of groove, but that the tool leave no fine scratches. This last mentioned condition is nearly impossible to fulfill. The hardest and sharpest tool will tear the machined part more or less, leaving cracks and scratches of greater or less extent on the machined surface.

"The obvious answer to this condition is to fill up these cracks and scratches by plastic flow of metal produced by a rolling pressure in the grooves."

The above quoted paragraphs are from a review of "Strengthening the Vibrational Resistance of Threaded Metal by Surface Pressing" by W. Isemer in MITTEILUNGEN DES WOHLER INSTITUES, No. 8, 1931, and published in WORLD PETROLEUM for March 1937 on page 61.



SUGGESTED IMPROVEMENTS

As mentioned above the ordinary threads used in attaching tool joints to drill pipe are of the "V" type. Even though these threads are slightly rounded, as in the A.P.I. standard, there is an extremely effective concentration of stresses due to the abrupt change in the cross-sectional area, which results in metal fatigue and premature failure.

There are two means of correcting this deficiency or weakness in the ordinary drill pipe, the first of which is by building a truly rounded thread rather than the "V" thread with slightly rounded root and crest. This, of course, would necessitate the use of fewer threads per inch, but not deeper threads. Useful threads that may be suggested are based on the acme or on the worm thread with rounded roots and crests on radii approximately one-half the depth of the thread. The sine curve thread also eliminates all sharp angles. The machining should be done with tools that would avoid all extraneous scratches in the metal.

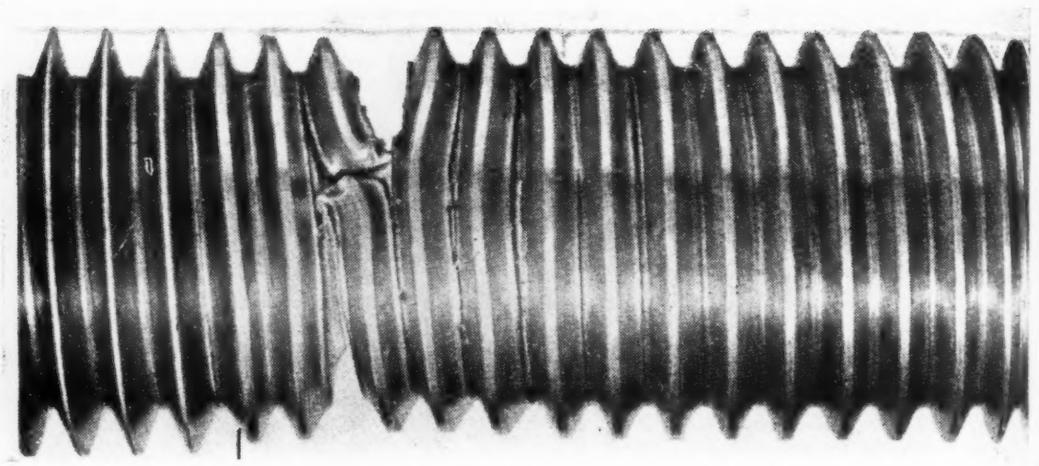
As a supplement to the rounded thread the modified shrink grip, slightly beveled shoulder or welded joint may be used.

A second method of accomplishing the rounded thread or of improving it is by rolling or pressing the root of the threaded section. "The efficacy of this operation was first proved by Isemer in an investigation that has not attracted as much attention as it seems to deserve. Isemer threaded section of rods of different steels and other metals and subjected these rods to vibrational stresses in a flexing machine until a permanent crack appeared. Where the thread grooves had not been rolled after cutting the break invariably appeared in the threaded portion; where the thread grooves had been rolled the break appeared outside the threaded portion.

"These results appear to point to the desirability of cutting threads to a round bottom, and then rolling to produce a crack and scratch-free surface. The pressure applied by Isemer to the single roll amounted to 3963 lbs.; for best results the roll should pass 15 times back and forth along the grooves. In this way Isemer proved that the vibrational resistance of his threaded rods could be increased 20 to 65 percent." (Opp. cit.)

CAUSE OF FATIGUE

Probably the greatest cause of metal fatigue in drill pipe is that harmonic vibration induced by the action of the bit on bottom in combination with its rotating speed and the periodicity of the mud laden fluid pulsation, and most particularly when more than the weight of the drill collar is carried on the bit on bottom. With a proper combination of these the maximum of vibration and consequent detrimental stresses may be



Photograph from Mittleilungen des Wohler-Instituts showing a threaded rod section tested in a vibrating machine—threads to the left were rolled while those to the right were not rolled.

induced. By altering one or more the shaft may be thrown out of "tune" and the harmonic vibrations disrupted. In many of the Mid-Continent fields, notably in Kansas, parts of Oklahoma and West Texas, the formations are such that certain combinations of values of the factors of the drilling operation, including type of bit, weight on bottom and speed of rotation, induce very violent fatiguing vibrations. High speeds are generally impractical, 40 to 80 rpm being the most useful and 150 to 200 rpm highly destructive of drill pipe through thread breaks caused by the concentration of these vibrational stresses in the root of the thread. In these areas a certain combination of these drilling factors results in "bouncing" of the drill pipe to a movement of probably as much as a quarter of an inch. This movement though not positively, apparently is at times synchronous with the pulsations of the pump. It is not supposed that the same motion, or any motion at all, takes place at the bit on bottom, but rather that the vibration begins there, reaches the middle of the curve or zero movement immediately above the drill collar or where the shaft is neither in compression nor tension, and the maximum motion as the upper free end of the drilling shaft is approached. At the point of zero movement or at the middle point of the wave, the molecular movements of the metal of the pipe are in opposite directions, hence the maximum stresses are at this median point of the harmonic curve, and therefore, we find the greatest fatigue and largest percentage of pipe failures there. With proper drill collar lengths this point can be thrown into the heavy section of the drill collar.

In the Mid-Continent areas it is customary to use very short drill collars, say, 20 to 40 ft., and carry 8 to 12 tons of weight on the bit. Rotating speeds are generally under 100 rpm. This entirely eliminates the vibration of higher speeds and in consequence avoids metal fatigue due to those causes. However, the pipe is rotated in compression and is subject to compressional fatigue where an universal joint motion obtains.

In other areas, particularly in certain fields of California, drill pipe vibration occurs at rotating speeds under 140 rpm. By increasing the speed to as much as 200 or even 250 rpm the vibrations are entirely eliminated and metal fatigue due thereto avoided.

By a proper study of the functions of rotary drilling, fatigue caused by extraneous phenomena may be avoided. Assuming that thread designs and methods of attaching tool joints to drill pipe can be perfected to a proper degree, then the useful life of drill pipe should be greatly lengthened and at the same time the depth capacity of the drilling string likewise increased. Despite the fact that the drill pipe is the most important tool of the rotary string and is subject to the severest labor, it transmits many fewer horsepower hours within its useful life than a shaft of similar original strength in practically any other service.

It may not be expected, reasonably, that the rotary drilling shaft should be able to transmit as many horsepower hours as can an ordinary shaft in other service but certainly by proper use of the tool, the elimination of weaknesses of design and the employment of suitable steels a vastly improved useful life may be obtained and its depth capacity greatly increased. These are essentials in the economically efficient development of the more difficult fields of today and particularly of the deeper wells yet to be drilled.

SUGGESTED IMPROVEMENTS

In using the shrink grip principle of attaching tool joints to drill pipe, caution in design and practice must be exercised to avoid shrinking the tool joint onto the pipe with too great a difference in diametric sizes. Experiments in the building of shafts and actual experience in the shop and in the field prove the likelihood of failure beneath and near the end of the severely shrunken collar. For this reason a shrink fit that is tight enough to hold without the use of threads of some character will probably not serve effectively for oil field use. An extremely interesting discussion of pressed and shrunken fitted members on shafts may be found in a paper entitled "Fatigue of Shafts at Fitted Members, With a Related Photoelastic Analysis" by R. E. Peterson and A. M. Wahl of Westinghouse Research Laboratories, Pittsburgh.

It might be expected that the welding of the tool joint to the threaded pipe would set up stresses upon cooling and consequent strains that would be detrimental to the strength of the shaft. Experience indicates that although this may be true, the cross-sectional area weakened during the process of welding or cooling, is still stronger than other cross sections. Welding has not yet had an entirely fair trial and in consequence it is not definitely known to what extent pipe failures are avoided thereby, but the practice seems to be sound and very useful with the advantages substantially outweighing the disadvantages.

With such structural deficiencies as thread form and too rapid changes in cross-sectional areas corrected, it will then be possible to make a fundamental change in drill pipe design. By using a rounded or a rolled thread the drill pipe may be made of the same internal diameter throughout its length and upset externally to an extent not exceeding 1/16th of an inch on the radius more than the depth of the threads. The tool joint size may then be held to its present dimension, or increased to that which will permit a sufficiently strong pin and box. It is highly important to maintain the largest possible diameter of the drill pipe, because with the present inherent weaknesses eliminated, then the body of the pipe itself will be the weakest part of the drilling string. At the same time we are limited in the size of pipe to be used to drill a hole of a given diameter by the necessary outside diameter of the tool joint. Also it is highly important, for the benefit of the most important factor in drilling, namely, mud laden fluid, that the inside of the pipe be flush and of the largest possible diameter. By the use of these rounded threads, then, the maximum possi-

ble pipe diameter for the minimum possible tool joint diameter with internal flush walls, can be maintained. The present type of tool joint pin cannot be used for this purpose. It must be of the step thread type or the present taper must be altered to a much lesser angle. At the present about four revolutions of the drill pipe are required to make up the tool joint. However, in spinning up these joints there is sufficient length of spinning line around the pipe to rotate it several times four revolutions. Therefore, an increase to six or even eight turns to make shoulder to shoulder contact would not be detrimental to the speed of the drilling operation.

In passing, it would be well to mention other very desirable features of such pipe. Being flush inside, it may be used for swabbing and testing operations, and in the smallest sizes, when the drilling string has reached the end of its useful life, it can still see service as tubing. In the larger sizes the drill pipe may be run and cemented in the hole as casing. This change alone would effect an enormous saving in drill pipe or casing and tubing costs, and would eliminate the tendency to use drill pipe beyond its normal useful life.

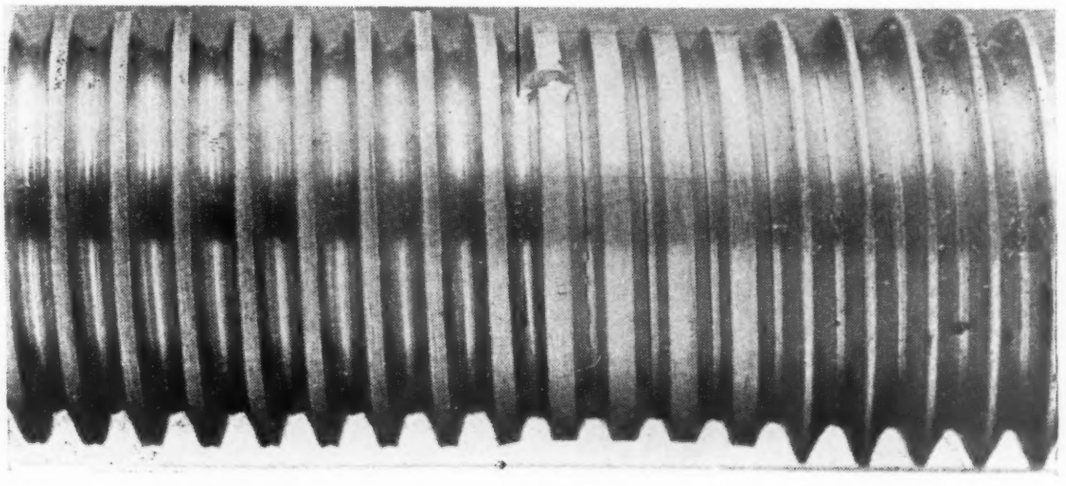
An additional method of drill pipe manufacture or design that deserves very serious consideration is that having the tool joint box and pin as integral parts of the pipe. In the diamond drilling industry, where external flush pipe is used, this principle of manufacture has been used for years and now one tubular goods mill is building an externally upset pipe, internally flush, with integral joints for oilfield service. It seems probable that a successful pipe of this type must be built of an alloy steel such as presently used in the manufacture of tool joints, and heat treated to a hardness approximating 300 Brinnell, to avoid excessive tool joint wear. Also the upsets must be sufficiently long to permit the use of drill pipe tongs on the upset. Their use on the thin body of the tube causes collapse. The cost of such pipe will at first glance be considered prohibitive, but if it has a useful life commensurate with its cost it can be used practically. In view of the predominance of pipe failures within the first few hundred feet above the drill collars it may be worth while to use heat treated alloy steel for that section of the string most subject to failure.

The danger of a sharp or "V" thread for use on drill pipe is (1) due to the concentration of stresses and consequent metal fatigue at the root of the threads, and (2) during the operation of cutting the thread the metal of the pipe is subjected to a severe wedging action, particularly when the tools are not perfectly sharp, with a consequent development of fatigue due to the actual cutting operations. In addition to this fatigue so developed, actual cracks in the root of threads have been found prior to any service rendered by the tube. This latter, however, is a rarity, but at least it is one more reason why the present thread form should be abandoned.

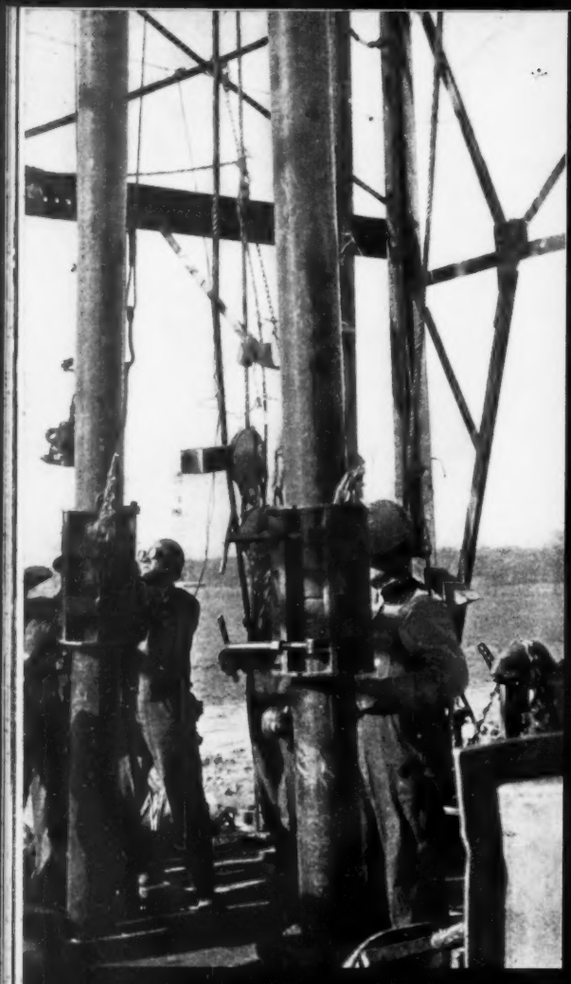
Pipe failures may likewise be caused by phosphorus banding in rolled plates or tubes and by inclusions of scale or slag rolled in and banded in a similar manner. High carbon streaks are equally effective. The photographs (1–2–3–4–5) clearly show these conditions and the detrimental effects of such banding are readily seen.

A practical definition, or more correctly, explanation of metal fatigue does not seem out of place at this point, in view of the fact that it will be helpful in understanding the cause of pipe failures. All steel is built up of crystals. Practically all crystals are formed in planes of molecular gliding or layers capable of splitting along these cleavage planes to sheets of molecular thinness. A splendid example is mica or "isinglass" which crystallizes in hexagonal columns having cleavage planes normal to or at right angles to the major axis and which may be split off from the crystal in extremely thin plates. Steel crystals are no different in principle. When a given cross section of steel is subjected to stresses and movement within the crystal body of the metal, slippage develops along these molecular gliding or cleavage planes, they being the planes of greatest weakness. Eventually one of these slippages will develop into a microscopic fissure, which, with continuous stresses, may eventually develop into a crack that will pass out of the minute crystal and cross through or between the other crystals of the metal, thus developing a major weakness and final fatigue failure.

The photographs are (6) taken from a discussion by R. E. Peterson of Westinghouse Research Laboratories of a paper by A. V. DeForest entitled "The Rate of Growth of Fatigue Cracks." The four micro-photographs are of the same piece of steel subjected progressively to greater and greater fatiguing stresses. Cut (a) shows the polished section of steel before fatigue has set in. In (b) the arrow "A" points to the appearance of slippage along a molecular plane that becomes progressively more prominent in (c) and finally develops into a definite crack in (d). Many other planes of molecular cleavage appear in (b) and they become much more abundant in (c) and (d) which have been subjected to the progressively greater fatiguing stresses.



Another view of the same rod section as above with rolled threads to left and unrolled to the right. In both pictures it should be noticed that the most prominent cracks or failure are adjacent to the rolled and stronger thread section.



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STORY OF FIRST WELDED CASING

in Mid Continent Told in Pictures

A 5,968 ft. string of casing was welded as it was being run in the hole of the Carter Oil Company's No. 4 W. T. Miller in the Crescent Field, Oklahoma. The casing was 36 lb. 8⅝ in. and the operation was accomplished successfully only after careful previous study by Carter engineers.

1 Lining up with the line-up clamps attached. One section of casing has been lowered into a rat hole; the second section is lowered on top of it.

2 Tacking or making a small weld in a few places to hold the pipe in position so that the line-up clamp can be removed.

3 The bevelled pipe stacked on the rack in 40 ft. lengths.

4 The completed weld. The whole job was completed in less than 30 hours.

5 The special pick-up clamp and line-up clamp designed and constructed by Carter engineers.

6 The pick-up clamp attached to the casing.

7 One of the trucks containing an electric welding unit.

8 This picture shows the two columns of pipe standing in the derrick at a height of 80 ft.

9 Welding: Four welders and two helpers were at work at all times. Three extra welders stood by. Electric power was furnished by four generators near the well.

10 A night picture of the welding.

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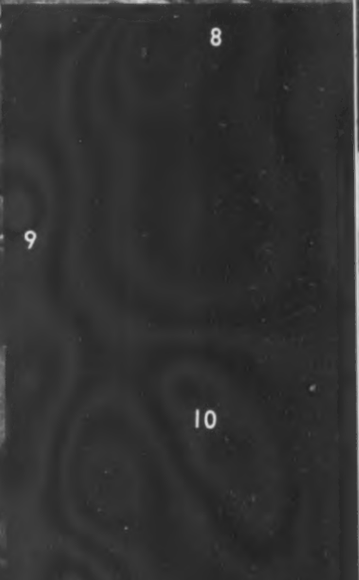

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TRENDS in Design of Drilling Equipment

Refinements in Design of Steam Engines, Heavier Slush Pumps, Pressure Heads, Drill Pipe Threads, Increase Efficiency and Speed of Drilling

As in most other branches of human activity, progress and improvement in the art of winning petroleum from the earth is a continuous process. It is also a varied process, characterized by the appearance of conflicting ideas as to the best way of doing a certain thing or of meeting a given situation.

On the question of what is a or the most desirable way of producing oil there is no difference of opinion anywhere. On that question the final answer is given by the figures which show the profit per barrel that has been realized from the product of an oil well during its effective life. Viewed from this angle the criterion to be applied to any new or old operation in oil production is: does it make a noticeable contribution toward the reduction of production costs so as to widen the margin of ultimate profit? In this sense the petroleum industry (like most others) is a one-idea industry: to make the most profit by keeping costs in line with maximum efficiency.

The practical difficulty arises when a choice of means has to be made, and out of a variety of means, each of which has its enthusiastic advocates, to choose the best.

Among those divisions of oil field practice on which there is a variety of opinion and practice is the large item of power supply. It takes a lot of power, and therefore a lot of fuel, to sink an oil well, particularly when, as is always the case, time is "of the essence," or as the practical man puts it: time is money.

There are three recognized methods of generating and applying power in oil production: by steam engines, by direct connected Diesel engines, and by electric motors actuated by one or other of these two prime movers. These various types have their advocates, not the least interested being their respective manufacturers, each of whom is trying to outdo the other in placing convincing facts and figures before the oilmen. And it is precisely this rivalry among manufacturers of competitive equipment that writes the record of much progress in the drilling of wells and the production of oil.

The earliest in date and still the most extensively used prime mover employed in drilling is the steam engine. Because of its superior speed and flexibility, steam equipment is much preferred, especially in rotary drilling. But along with its undoubted qualities the old style oil field steam engine had, and in many cases still has, countervailing disadvantages. It is bulky and heavy, and consequently difficult to move. But the chief complaint against it has been its relative inefficiency as a converter of the energy contained in the fuel supplied to it. By comparison, the Diesel engine is far superior to the old style oil field engine, so the manufacturers of steam engines have had to seek ways of overcoming this competitive handicap. As a result the oil field steam engine has now acquired and is still in process of acquiring many of the refinements that have long been standard practice in less migratory industries.

The most obvious of these necessary improvements is the growing use of feed water heaters that save the heat in exhaust steam, a practice which goes a long way to reduce fuel expense. A more recent forward step is the introduction of superheaters, which still further increase the amount of power obtainable from a given weight of fuel. Besides fuel saving superheat results in notable operating improvement. When the steam boiler is furnishing only saturated steam there is apt to be excessive condensation, resulting in sluggish operation of the engine. With super-saturated steam the engine operates more efficiently, lubricates more effectively and makes quicker response to unusual or sudden demands, all of which contributes to lower costs. So the up-to-date oilfield steam plant has at least a built-in superheater; better still is a separately fired superheater which can be by-passed or cut in as occasion requires.

In the matter of fuel economy a long forward step was taken by abandonment of the direct acting slush pump, which in the not remote past consumed up to 70 percent of the total steam generated. This is because the direct acting pump is unable to make effective use of the expansive force of the steam. This inconvenience is now obviated by driving the pump from the engine, and so taking advantage of the fly-wheel effect of the latter; in this way steam consumption by the pump may be reduced by at least a third.

Even this improvement has not exhausted the possibilities of steam economy in the oil fields. Not so long ago it was, and in many cases still is, the practice to drive the rotary table by chains from engine to hoist and from hoist to rotary table. This is an uneconomical way of driving the table, which by itself consumes little power in comparison with the capacity of the hoisting engine, which is in use only about a fifth of the time; this circumstance imposes on the engine an unfavorable load factor. This disability has led to the development of a separate small engine for the rotary table so that this engine can operate at all times with a favorable load factor; connection with the rotary table is made through a gear box of suitable ratio to provide a desired range of drilling speeds. Such an arrangement well accounts for a saving of about 20 percent of the steam that would otherwise be consumed in driving the rotary table from the hoisting engine. It also eliminates the wear, tear, and noise of the chain drive.

Still further economy in the consumption of steam is effected by providing the up-to-date oil field steam engine with a hand controlled variable steam cut-off instead of the throttle valve for reducing the power output. The driller can thus cut admission of steam to the cylinders anywhere between 25 percent and the maximum cut-off (approximately 85 percent). When the full power is not needed the cut-off may be shortened to 30 percent, for instance, and the expansive force of the steam utilized for 70 percent. Since the full power is required only a small proportion of the time the saving of steam is considerable. The cut-off is subject to remote control from the driller's position.

Excellent steam economy may be provided by a dual drive arrangement for driving the rotary table and the slush pump simultaneously, but for maximum flexibility a separate rotary drilling unit is to be preferred.

Besides the foregoing improvements in working economy, the modern oil field engine has changed its form from the horizontal to the vertical. This change admits of a stronger construction, reduces load and consequently wear on moving parts, minimizes vibration, saves space and makes it possible to place the engine on a foundation entirely separate from and at any desired level below the derrick floor.

Seamless external upset tubing with rounded threads.

Such, in brief, are the evolutionary steps by which the oil field steam engine has acquired and is maintaining its position in the industry. The perfect oilfield steam engine may not have yet appeared but where an observer finds at an oil rig a twin vertical steam engine efficiently equipped with superheat and hooked up to deliver the exact amount of power separately required by the drill, the hoist and the slush pump, and with the input of power under the ready control of the driller, he will see a steam power plant that corresponds to the most approved ideas of the present time.

It may be added that the steam engine, along with its companion equipment, has (as is well known) also acquired portability. These portable power plants may consist of two relatively small dual drive vertical steam engines mounted in line with power take-offs on a structural steel base to form a self-contained prime mover for an entire rotary drilling rig. The equipment is so arranged that in regular drilling service the engines operate independently—one on the slush pump and one on the drill—but for hoisting are connected and then operate as a single prime mover.

However, the steam engine has to meet rather formidable competition from the Diesel engine, which has also undergone and is still undergoing evolution to fit it for the exacting conditions of oilfield work. The basic merit of the Diesel engine is, first of all, that it operates on cheap fuel oil, and that it generates more power from the fuel supplied to it than any other prime mover; hence it takes first rank in fuel economy. The Diesel engine is also considered capable of developing a greater power per pound of weight than any or at least most other prime movers. As now developed it is practically independent of cooling water, and so has the double advantage of usability in locations where fuel and water are relatively scarce. It occupies little space and needs no long pipe connections. On these natural advantages the builders of Diesel engines continue to add ruggedness and ability to function under the exacting conditions of oilfield work.

As now adopted for the oilfields the Diesel engine is designed to operate mainly on the four cycle principle. There may be single Diesel drilling engines that have to do all the work of the rig, but practice has mostly settled on one Diesel for the drawworks and the drill and another Diesel engine to drive the main slush pump and an auxiliary pump from a line shaft. As in the case of the modern oilfield steam engine the Diesel engine is under remote control of the driller.

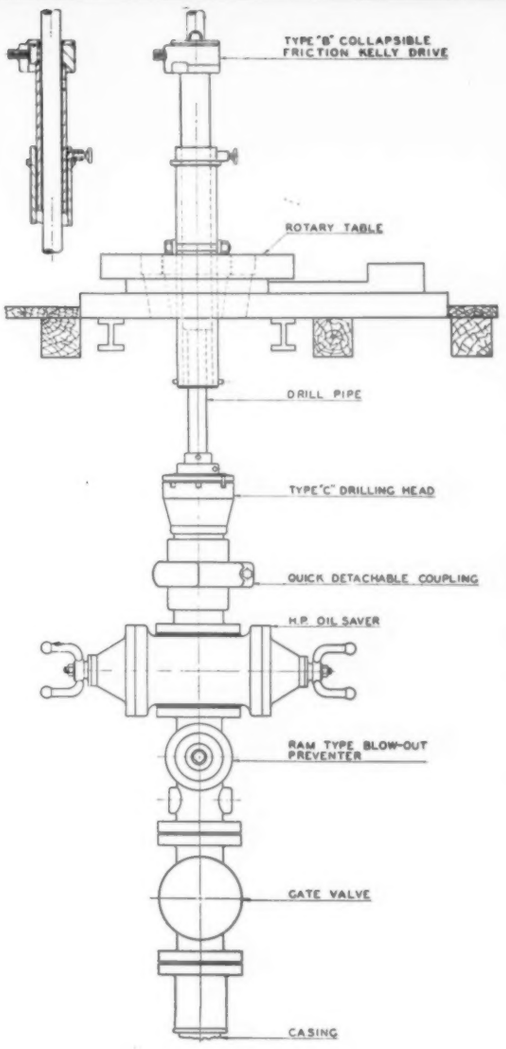
The Diesel engine as a source of power directly applied has a secure place, particularly in the small and medium sized rigs, including, of course, the portables. In its contemporary form, a Diesel rig for deep drilling will consist, for example, of a set of three 200 H.P. Diesel engines which generate electricity for a 400 H.P. drilling motor, for the drill and the drawworks and two 225 H.P. slush pumps. The generators are wound so as to give a drooping voltage when the motor torque decreases, which is equivalent to an infinite number of automatically changing gear ratios between the engine and drawworks, which is said to give a flexibility not duplicated by steam or other mechanical system, where the driller is continually in doubt as to what gear ratio to use.

A large place in current drilling practice is taken by the development of portable drilling rigs. One of the circumstances that has called forth this development is the expansion of exploratory work where new or little known fields are to be tested, and where there is need for caution against too expensive wildcatting. Portable rigs are also much in demand for occasions requiring haste in drilling, as in town lot oil fields where every surface owner must tap the oil below his land or see it flow out through wells sunk by his more forehanded neighbors. The drillers must lose the least possible amount of time in moving from one location to another; their rigs therefore must have a high degree of mobility. To meet this requirement a whole outfit is dimensioned for mounting on one or more trucks so that only a few hours need elapse between finishing one well and beginning another. These portable rigs are necessarily light and incapable of drilling wells of large diameter and great depth, but some portable rigs can make holes up to 6,500 ft. The main characteristics of a portable rig are its relatively small weight, approximately 20 tons, including the power plant; here is where the small weight of the Diesel engine shows up to advantage, but the steam engine is by no means shut out. Of late, the economy of the portable rig has given it a place even in old relatively shallow proven fields where there is no special reason for haste except on the general principle that, in any case, a change of location should consume as little time as possible.

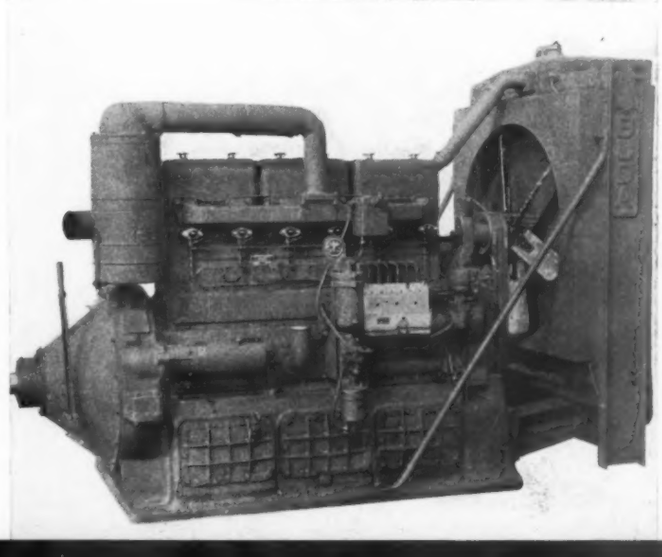
A development of the past few years has been pressure drilling, or drilling under pressure, where formation pressures or other phenomena give rise to problems which ordinary mud engineering cannot handle. These problems call for special equipment on the Christmas tree that may now be regarded as fairly standardized.

However, pressure drilling is being applied to cases where formation pressures create no special difficulties, or where for any reason the time-honored process is not altogether suitable.

One such special case is the drilling-in or completion of wells under pressure, using



Above: Hook-up for drilling in wells under pressure employing a collapsible friction kelly drive and a rotating blow-out preventer. Bottom, right: Friction kelly drive and tubing oil saver.



Recent type Diesel engine for oilfield service.

either water, gas, or a mixture of oil and gas as the circulating fluid. The use of oil as the circulating fluid is deemed especially advisable where the oil-bearing formation is likely to be fouled by a mud fluid; the practice in such cases is to drill down to the oil sand in the usual way, remove the ordinary mud and complete the well with circulating oil, the low hydrostatic pressure of the oil column being compensated by pressure applied at the surface.

Equipment for this purpose consists of a high pressure oil saver through which the drill pipe with tool joint may be run or pulled against the working pressure without leakage, and a special drilling head or blow-out preventer (see illustration). For rotating the drill stem use is made of a friction kelley drive which grips the pipe when drilling ahead until the top of the drive touches the rotary table, whereupon the clamp is loosened and a new hold taken higher up.

According to present experience the practice of completing wells under pressure with oil as slush medium gives a cleaner hole that justifies the small extra expense and trouble.

A few paragraphs above the oil industry was spoken of as one where the dominant idea is to get the most work done in the shortest possible time; this idea is born of the knowledge that time is money; or otherwise paraphrased, if an oilman saves his minutes, his dollars will take care of themselves. Hence everything within reason is or should be done to accelerate the rate of drilling, or hole-footage per day. Among the requisites

Above: Central pumping power supplying eleven wells. Right: Drilling in under pressure at Edmond, Oklahoma. Below: A modern Diesel drilling rig on the Texas Gulf Coast.

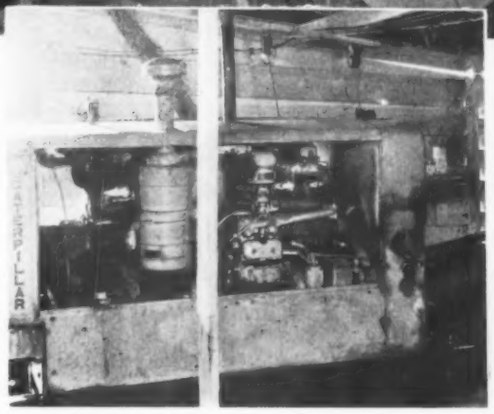
for speedy drilling is that the drill bit as it gnaws through the formations shall be kept free from the debris it creates, and not waste its energy in powdering material it has already loosened; therefore cuttings must be taken away the instant they are formed. The proper agent for this function is a circulating mud fluid in powerful movement. The proper agent for imparting powerful movement to a mud fluid is a powerful mud pump. And therein is one item in which the oil industry is trying to register progress: to develop mud pumps to the limit of capacity, which means both maximum circulation and high mud pressure. So mud pumps show a tendency to grow in size and energy.

While time is being saved by these giant slush pumps, the newer giant drawworks (see picture) are clipping minutes and seconds from the time required to make "round trips" in and out of wells with the drilling tools, etc. This is self-evidently a matter of no small importance in the numerous deeper wells that are being drilled. Besides speed, which is also a function of power, the occasion has called for careful design of lubricating arrangements, self-aligning roller bearings, cooled braking system, etc. Of course speed and safety have their price here, but they are worth it. In this connection some credit should be given to wire rope manufacturers for their efforts to increase the strength and wearing quality of their products.

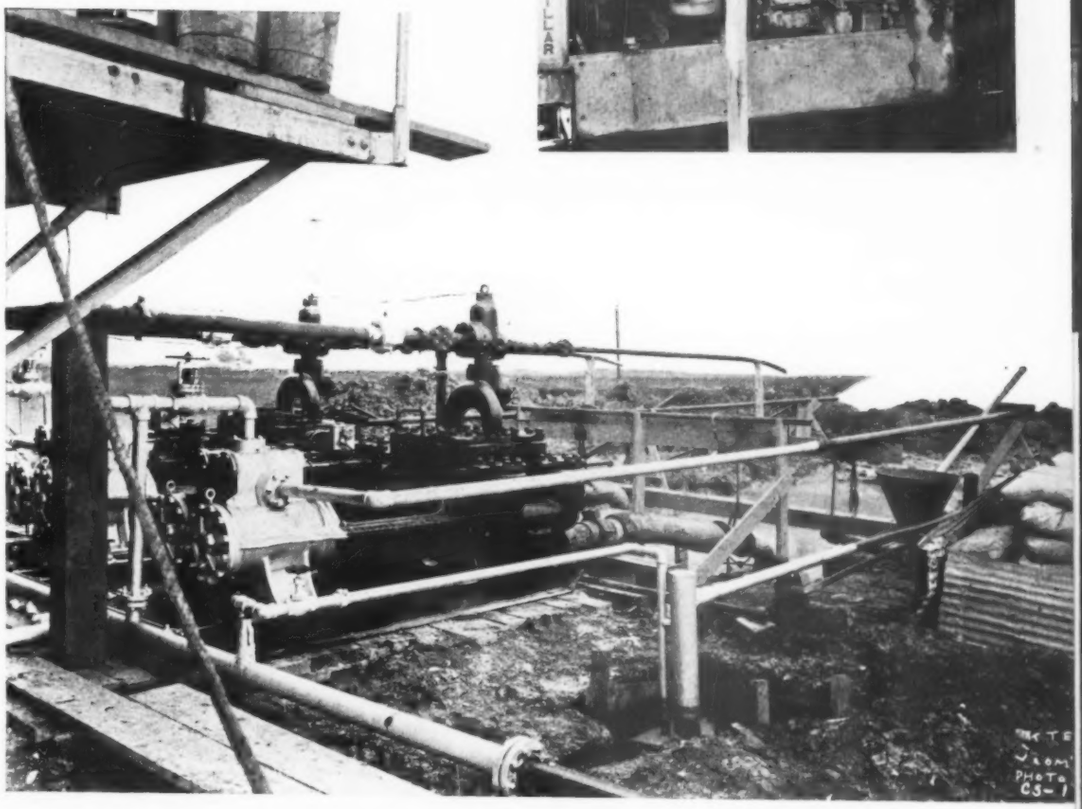
The Brantly rotary feed control, while not a particularly new development, has registered progress in the favor it has gained among operators who are anxious to obtain the most efficient possible service. The use of this device is equally agreeable to the driller, who is relieved from the business of continually riding the brake lever to keep the weight on the bit uniform, an operation that is now practically automatic and requires nothing more exacting than the adjustment of valves.

Not the least important of current oil well problems has to do with the steel casing that goes into the completed hole, and the drill pipe. Such tubing is necessarily made up in threaded joints, and these joints are a source of trouble and loss, because under the stress of drilling operations the long strings vibrate and develop cracks in the threaded portions, entailing breakages with the consequent inconveniences of such accidents. The efforts of pipe manufacturers have been directed toward making stronger threaded joints. One design (see illustration) provides for threads that are rounded on the top and bottom and having a considerable radius, so that joints formerly threaded 10 to the inch can now be threaded 8 to the inch and still leave approximately the same section of metal at the threaded end, which is considered a decided improvement over the conventional Briggs profile. It also has the virtue of faster make-up.

Another way of making up long strings of casing that has lately attracted favorable attention is to weld the joints as they are lowered into the hole. Operators who have started this innovation have developed a technique that is rapid and convenient. As the welded joints are stronger than the pipe itself, joint failure here simply disappears.



Above: Single pumping well with modern counterbalance. Right: Diesel operating oil rig at Chase, Kansas. Below: Heavy duty, high-pressure slush pumps.



After the drill has reached the productive horizon comes the matter of getting the oil out of the well. And here is another place where there has been room for progress in economy and convenience. Pumping equipment, for example, includes units for deep wells with a peak torque capacity of 450,000 inch-pounds at 20 strokes per min. and a 74-inch stroke. Other recently developed features are counterbalances that permit change of pumping stroke without changing the counterbalancing weights, retractable horse heads to avoid interferences with service operations, and large capacity power pumps direct-connected to engines for 6,000 bbl. per day at pressures up to 15,000 lbs. per sq. in.

Besides the few main subjects here touched upon are countless small items which in the aggregate contribute enormously to successful and low cost drilling. To notice all the improved drill bits, blow-out preventers, depthometers, non-stickable valves, and other convenient—even indispensable—accessories, would require far more space than is available.

© Robert Yarnell Richie

Well cementing operations by present customary method in Texas.

IMPROVED CEMENTING

by Two Period Squeeze Method

CEMENTING a string of casing in a well drilled for oil or gas is done for three primary reasons; first, and of most importance, to obtain a "water shut off." Second, to reinforce the steel casing by placing a solid cement layer between the steel and the wall of the hole, this being particularly important in very deep holes where the hydrostatic pressure to which the tube is subjected, closely approaches the compressive strength of the pipe. Third, casing is cemented for the purpose of preventing corrosive waters from gaining contact with the metal of the casing. Of these three objectives the first is of paramount importance. Under many conditions, however, the prevention of access of corrosive waters to the walls of the tube is of much greater importance than increasing the strength. In fact, up to depths of seven or eight thousand feet casing, having reasonable wall thickness, is quite strong enough. In the deeper wells that will become increasingly important in the future, the strengthening of the wall of the casing will require much more serious consideration.

Before entering into a description of the technique and materials employed, it would be well to review briefly the method presently employed for oil well cementing. On an ordinary job a float shoe is attached to the bottom joint of the casing string and generally a float collar between the bottom joint and the next joint above. The casing is made up and run into the hole to the desired point, the cementing head is then placed in the top of the casing and circulation is broken by starting the mud pumps. Assuming free circulation, the cement head is taken out and the bottom plug is placed in the casing head for the purpose of separating the cement from the drilling fluid. The cementing head is then replaced in the casing head, the cement mixed to a fluid slurry weighing about 120 pounds to the cubic foot and pumped through the cementing head and into the casing. The cement, thus introduced, pushes the plug downward to allow space for the slurry as introduced. When all the cement has been pumped into the casing the cementing head is taken off, the top plug placed in the pipe, the cementing head replaced and mud again pumped into the casing, forcing the plugs and cement downward until the top plug hits the float collar. The pumps cannot force fluid past the top plug, therefore they are shut down and the cement job is complete. The cement, which is now outside the casing and very much heavier than the mud inside the pipe, is prevented from passing back into the pipe by valves in the float shoe and float collar.

This job is done, except in rare accidental cases, with normal circulating pressures, taking into consideration the difference in weight between cement slurry and mud laden fluid. As the slurry passes beyond the shoe and into the hole it follows the lines of least circulating resistance, just as does the mud, nor does it enter formations whether of a coarsely porous or fractured type, except those voids which are entered by mud laden fluid. If there are pockets or stringers of mud and cuttings in the hole the cement passes around them and will not carry the solid column of mud and cuttings upward with it. This manner of placing cement between the casing and the wall of the hole means that there are many voids in so far as cement is concerned, porous zones are not entered and much channeling, undoubtedly results as the cement passes upward. This results in a very poor cement job which will not have a high average of water shut off where conditions are difficult and which offers no strengthening whatsoever to the walls of the pipe and does not in the least prevent access of corrosive waters to the steel. In other words the three objectives are either entirely missed or accomplished inadequately.

The new two period squeeze system of cementing is designed to correct the deficiencies of the usual method just described.

First, cements of two different characters are required: one of which will take its initial set in about two hours or slightly more; another that will take its initial set in not less than six hours and remain pumpable for at least four or five hours, or, if not pumpable, may be readily set in plastic flow by the exertion of sufficient pressure. The first of these cements is the common variety used in ordinary oil field work, while the second is a perfected product of the cement manufacturers and is readily available. In fact, the initial set can be delayed as much as twenty-four hours without in any way affecting the ultimate strength of the cement.

Assuming that in the case of a hypothetical well five hundred bags of cement are required to do the cement job and that the "two period squeeze" method is to be used. Casing is run in the usual manner, the bottom plug is placed in the pipe and cement pumped in: first, one hundred bags of ordinary two-hour cement and next, four hundred bags of six-hour cement. The top plug is then put in and the slurry is displaced by measurement, leaving approximately fifty bags of

cement in the casing. The job is then allowed to stand until the fast setting cement has been wet for three hours, after which the pumps are started and the remaining fifty bags left in the pipe, displaced behind the casing if possible. If it can be displaced it will probably be done under very high pressures, up to 2,500 lbs. per sq. in. and will give the most effective results. In these circumstances slurry is moving under high pressure between the wall of the casing and the wall of the hole and is put away into porous formation. It should close or scour clean all channels and eliminate the presence of mud voids and mud pockets. It is very similar to the ordinary squeeze job which practically always gets a water shut off when it is of necessity done.

If the 50 bags of cement cannot be displaced from the pipe, then the so-called squeeze job is done: pressure is built up to the maximum that is safe for the casing being used and is held there until it has set, or for the usual 24 hours before releasing the pressure.

The quantity of cement to be used depends upon the formations that should be cemented off from the metal. This is readily calculated, and, where corrosive water sand is 1,000 ft. above the casing shoe then the packer of fast setting cement should be placed safely above the water sand at around 1,200 ft. and the slow setting cement run in the usual manner. In the event the trouble lies with a water sand near the shoe smaller quantities may be employed, the idea being to place the fast setting cement packer safely above the water sand and then displace slow setting cement into the pores of the water sand if possible, and if not, building a solid, impervious cement wall between the steel and the wall of the hole.

Some samples of cores showing bedding planes.

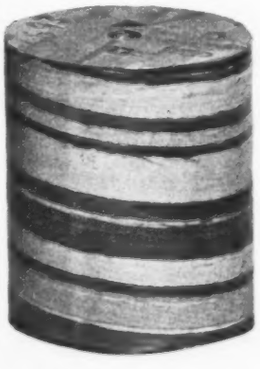
Magnetic Method of Orienting Cores

by G. L. Kothny

(Vice President Sperry-Sun Well Surveying Company.)

IT HAS long been customary to obtain samples from the earth's strata by employing diamond core drills or core drills of other types either rotary or percussive. Attempts have been made, by orienting the core barrel out of the bore hole or by attaching gyroscopic and magnetic compasses to the core barrel and by various other means to orient the core or determine its original position in the earth. When this fact is known the dip and strike of sub-surface strata intersecting the core so that traces of it are shown on its outer surface may readily be determined.

Dip and strike of formation may be determined from core after orientation.



Such methods have several very evident disadvantages. It is necessary to suspend regular drilling while special runs are made with orienting core barrels, and such runs must be repeated until a core showing satisfactory bedding planes is secured. The work can only be done for the immediate strata which are being penetrated by the core barrel. In other words, strata already penetrated even though the cores may be available are closed books so far as these methods of obtaining their dip and strike are concerned.

It has been discovered that most sedimentary rocks have a slight permanent magnetic polarity in the direction of the earth's magnetic field. This does not apply to pure limestones, anhydrite, or salt, but to sandstones and shales of normal iron content, in which small particles of magnetic minerals derived from older rocks have been more or less oriented in the earth's field while settling through water, and have been further magnetized through standing in this field through millions of years since they were laid down.

Sperry-Sun Well Surveying Company recently have opened a laboratory for orienting cores, and reliably determining the dip and strike of any intersecting bedding plane. This method covers determining the magnetic polarity of the core samples, that is, the direction in which the earth's magnetic field has magnetized the samples, orienting the samples to correspond with the original position in the earth and measuring the dip and strike of the stratification in the core.

The information is obtained by means of a highly sensitive magnetometer which automatically and photographically records the polarity of the core samples. The information which is rendered is the average orientation of the bedding plane of the samples submitted in a set of not less than three or not more than five.

Although it is preferable to receive fresh cores, cores which have been removed from the well for long periods may be used so long as they have not been exposed to magnetic influences and as long as the top or upper end of the core is accurately shown.

With this method it is not necessary to interfere with the progress of drilling. Cores showing satisfactory bedding may be selected from the trays containing the cores taken by standard rotary core barrels in the ordinary course of drilling, and can be oriented by an investigation of their magnetic properties provided their upper end is known. To determine the dip and strike of the strata in which they lie it is also necessary that some indication of a bedding plane be visible on the body of the core. This may be a line of foraminifera, a fracture, or any other indication of a bedding plane.

The method of service is as follows: One set of not less than three and not more than five samples at least two inches in diameter and three inches long, of preferably fresh cores with visible indications of a bedding plane obtained from within a range of depth of 30 to 50 feet, carefully packed to avoid breakage, is mailed to the Laboratory at 549 East Bixby Road, Long Beach, California. The cores must be marked "Top" and "Bottom." The samples should be accompanied by a letter stating the depth at which they were taken, also identifying the well by a Code Number and its approximate location by naming the Field, County and State. The inclination and its direction of that part of the hole from which core samples originate should also be given.

MAJOR FIELD Indicated

In Turner Valley, Alberta

By R. C. ROWE

THE QUESTION of whether the Turner Valley naptha-gas field is going to develop into a crude oil field of major proportions is attracting a good deal of attention in Canada at the present time, and the area is the scene of great activity which may have far-reaching results in the whole foothills region of Alberta. Turner Valley has been a producer of naptha-soaked gas for some years, and opinion had reconciled itself to the probability that it would be nothing else; but certain developments have caused a drastic revision of these ideas.

Turner Valley is located about 35 miles southwest of Calgary, in the province of Alberta. It lies in the foothills region of the Rocky Mountains, and has now been the object of three oil booms. It first came into prominence in 1911 when gas seepages were observed along the banks of Sheep Creek. On 25th January, 1913, the first drill hole was started and was completed during the following May. Its depth was 2,718 ft. and it blew in with a production of about 1,500,000 cu. ft. of gas and a few barrels of oil. This event started oil-boom No. 1, which was an occasion of frenzied financing and of very little real development, the latter statement being attested by the fact that by 1920 there were only nine completed wells in the area, none of which was of startling value. During that year Royalite Oil Company was formed through a reorganization of Calgary Petroleum Products which had made brave efforts to develop the field, but which had run into persistent bad luck.

Up to 1920, oil production had been from beds of Cretaceous sands which were overlying limestones of Carboniferous age, and a theory was formed that the gas and oil in the sands owed their origin to a deep-seated oil reservoir, and the Royalite Company undertook to test the matter out by driving a deep well which would tap the underlying structure. The well for this purpose, Royalite No. 4, was spudded in during September 1922, and completed in 1924.

It did not strike any great oil reservoir; but when it penetrated the limestone it blew in with a tremendous flow of naptha-saturated gas. After catching fire, Royalite No. 4 was brought under control and produced as high as 600 bbl. of naptha daily. This event started Turner Valley off on oil-boom No. 2; but it was a much better boom than No. 1 because the field entered an era of real development. A great number of wells were drilled and most of them were productive. Some were highly profitable, others were practically non-commercial; but between the two, most operating companies struck a fair average. Naturally there were disappointments. The structure was complex, and there was some of the inefficiency which always accompanies a pioneer operation. Dry spots in the limestone were few; but a few wells drilled out on the east flank of the valley missed the limestone altogether, because it is cut off by a fault. In time, however, the line of fault was established, and the eastern limit of the field was defined.

For some twelve years Turner Valley was developed as a naptha-gas field. Great numbers of wells were drilled, and absorption plants were constructed. An unfortunate feature of this period was the tremendous waste of natural gas; but eventually conservation measures were brought into effect and production was put on a quota basis.

At this point some brief comment upon the structure of the field is in order. The Turner gas-oil field occurs in the usual anticline—the axis of which runs in a general north-south direction with flanks pitching east and west. The east flank is cut off by a fault which displaces the limestone, and thus establishes the eastern limits of the field. It is on the west flank of the anticline that the present development is taking place.

Up until quite recently drilling has been confined to the crest of the structure. As already stated the east flank is cut off by a fault, and drilling in this direction is therefore quite definitely limited. No attempt was made to explore the west flank. This was largely because very deep wells were

Drilling at the southern extension of the Turner Valley field.

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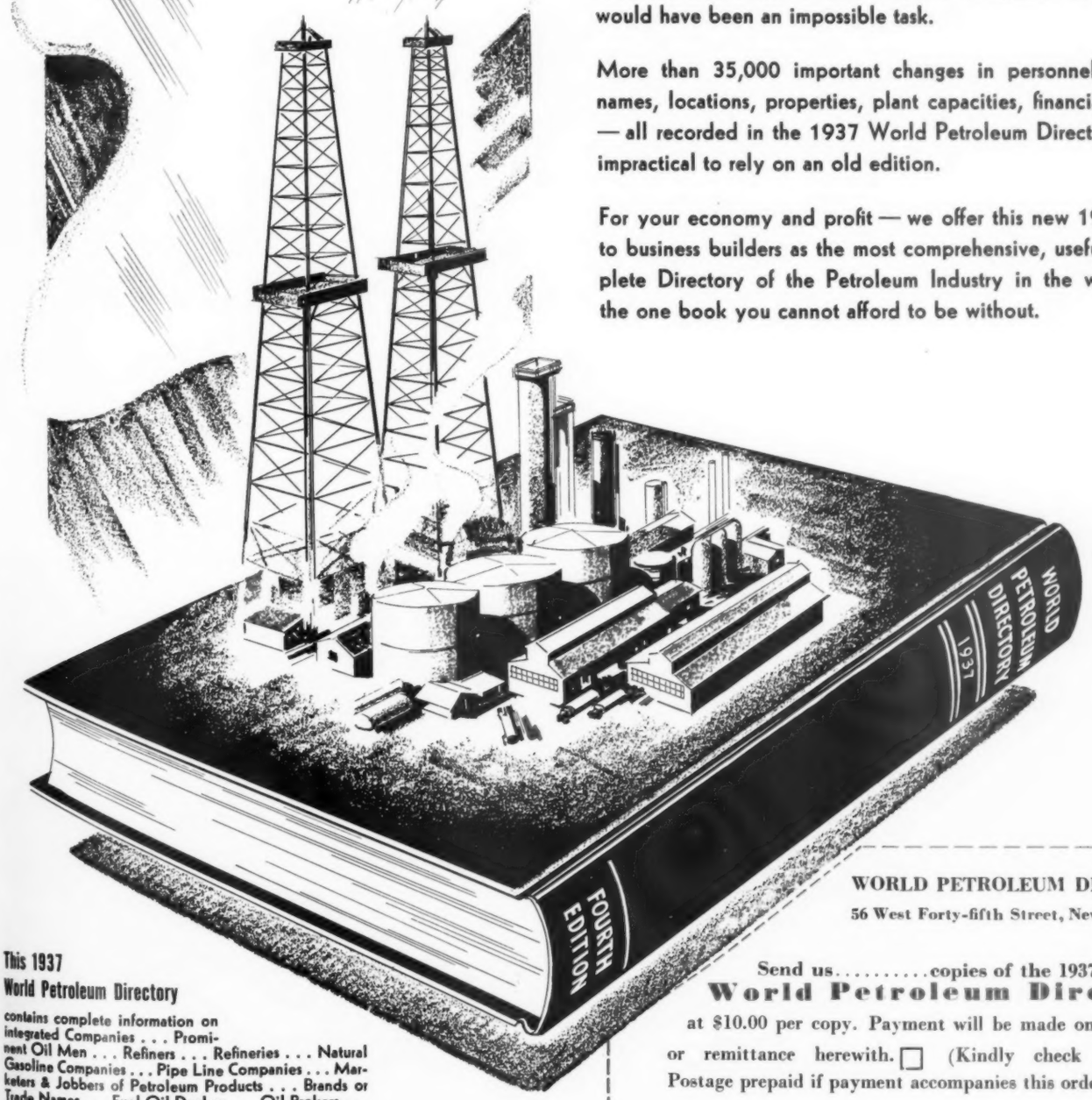

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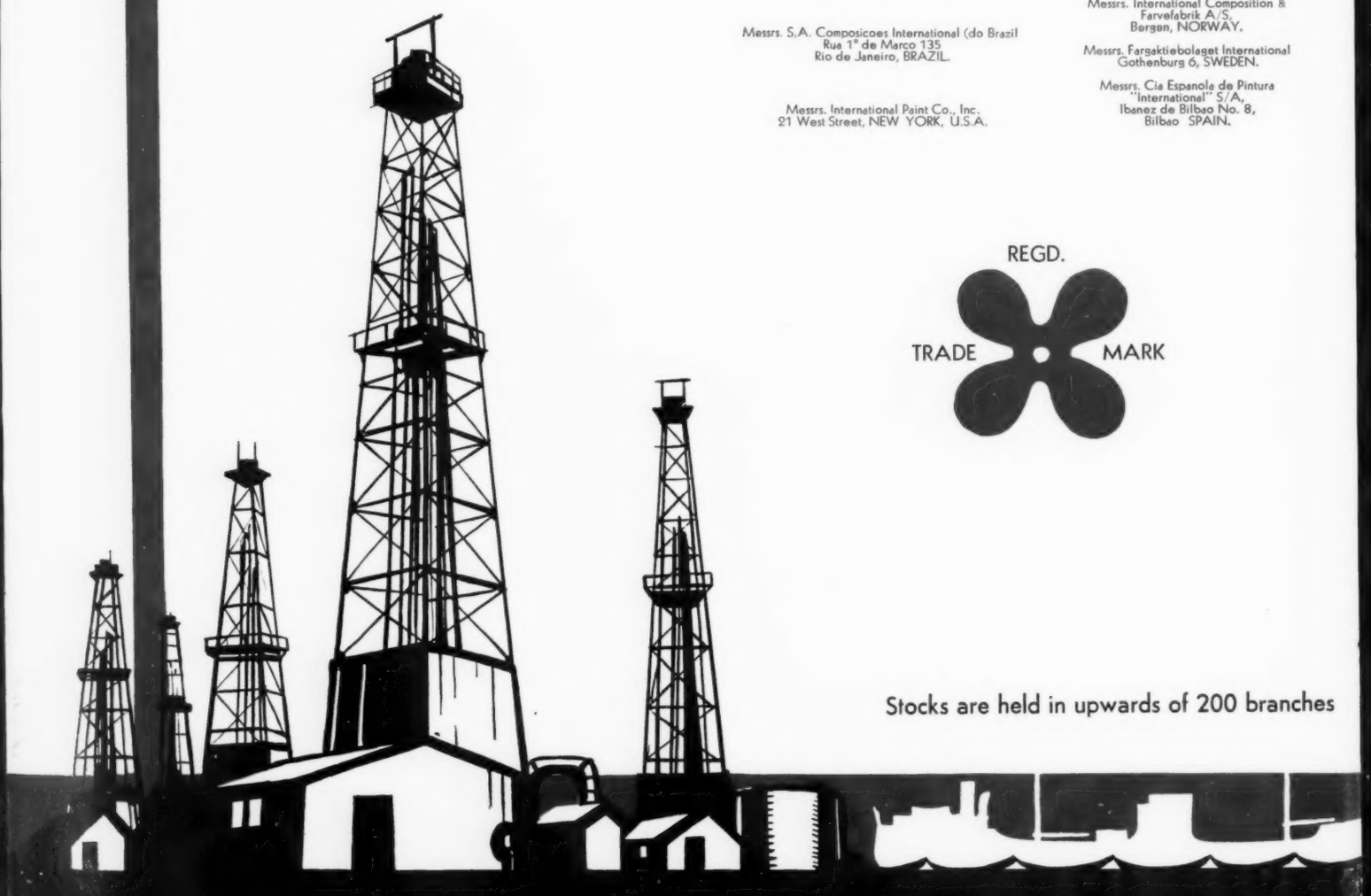

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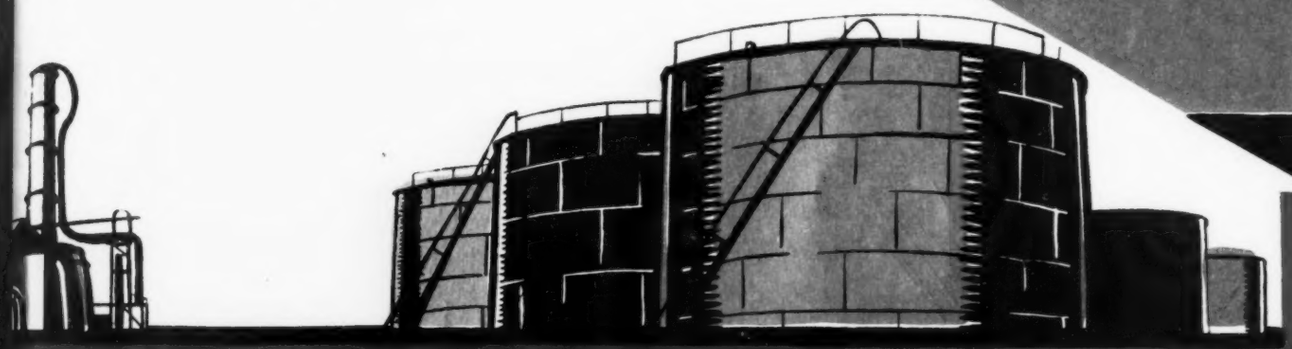

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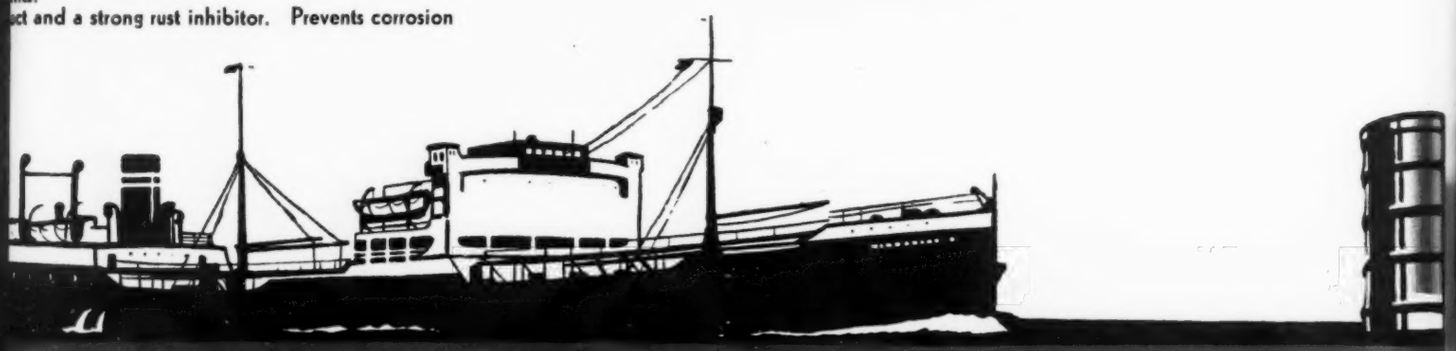

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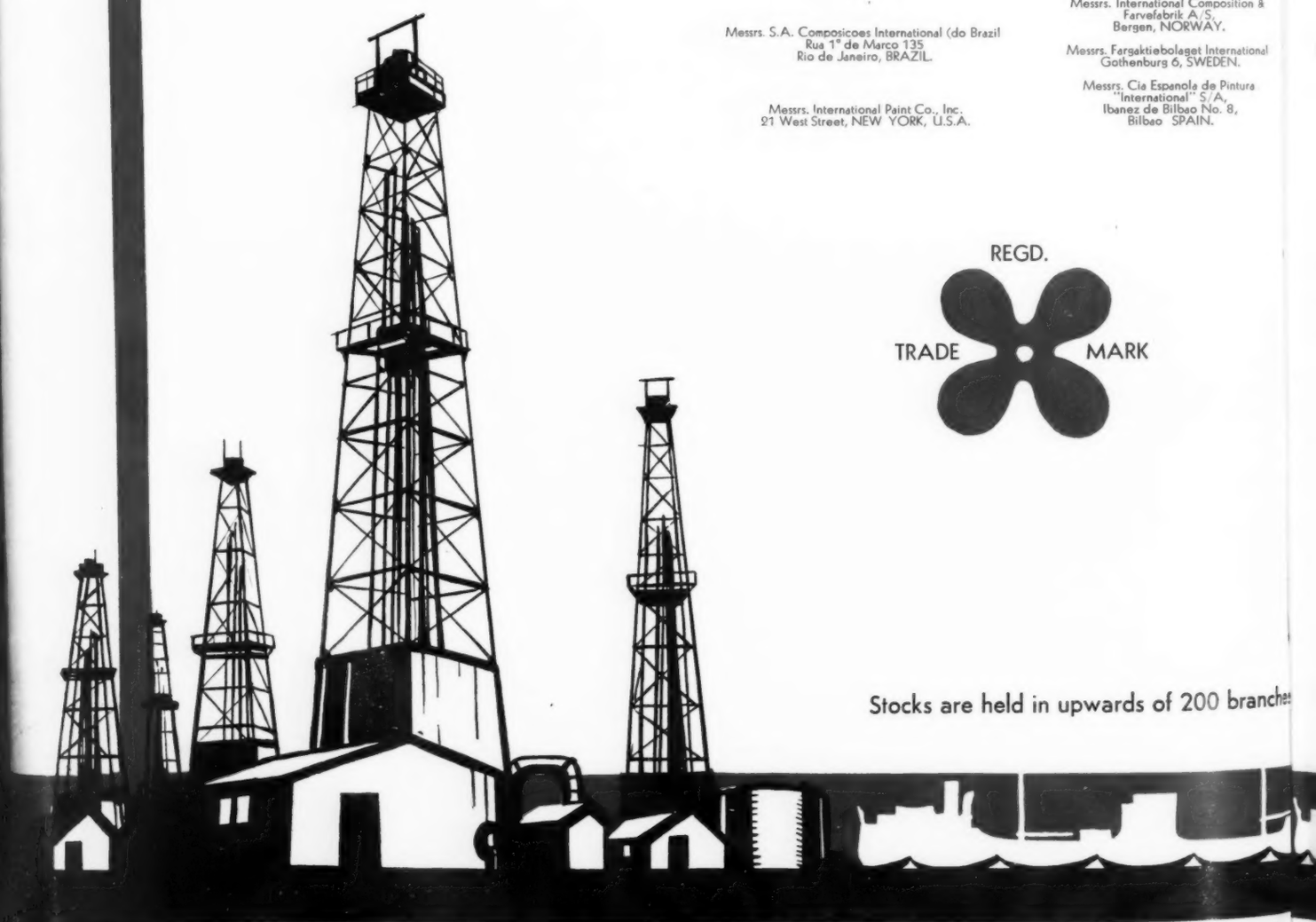

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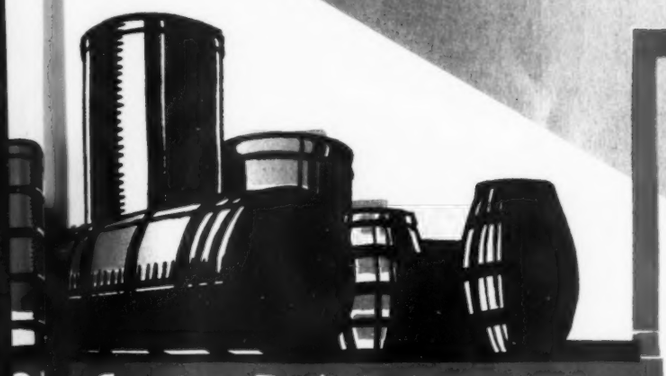

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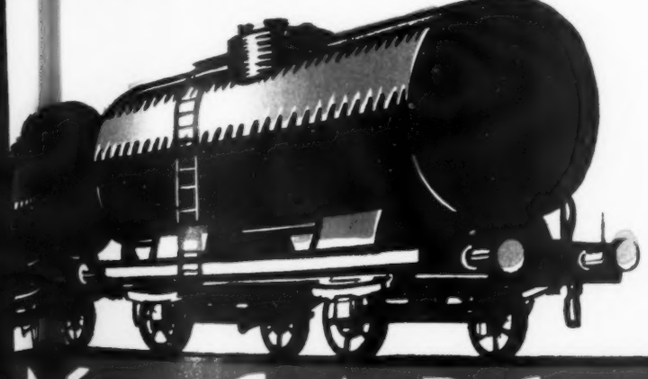

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necessary to reach the productive limestone, owing to the dip of the structure, and there was no particular reason to expect any results differing from those being obtained at the crest. In fact, certain shades of geologic opinion tended to discourage any exploration of the west flank. It was the opinion of many geologists that the folding of the Turner Valley structure was caused by the over-thrusting of the foothills mass along a low angle fault. The acceptance of this theory automatically involved the acceptance of a displacement of the limestone on both flanks, which in its turn meant that the limestone was cut off from its roots. As the limestone is the host of the gas and oil, it is obvious that the entertainment of this theory quite effectively limited the possibilities of the field.

Thus the matter rested for some years; but in 1930 a well was completed which finally changed the whole complexion of Turner Valley. The well in question was Model No. 1, which was drilled in the north end of the valley, and was slightly off the crest of the structure, and slightly down on the west flank. Model No. 1 was drilled as a naptha-gas well, and it ran true to form by coming into production with about 155 bbl. of 68 A.P.I. gravity naptha from 4,000,000 cu. ft. of gas. It continued as such for a while, but as time went on the character of the production changed. The amount of oil remained much the same; but the amount of gas dropped. More important still, the character of the oil changed, until it became quite obvious that Model No. 1 was producing crude oil, and to-day the well produces about 150 bbl. of 46 A.P.I. gravity crude from 500,000 cu. ft. of gas.

It is not hard to imagine that this transition occasioned a great deal of speculation. It was obvious that there was a migration of crude oil into the naptha-gas reservoir, and it was equally obvious that it could only be coming up the west flank. It was a simple step of deduction from this point to the conclusion that there is a crude oil reservoir on the west flank of Turner Valley, and that, as pressures decreased in the naptha-gas reservoir, the crude migrated up the flank, its movement possibly being due to a water drive. Another piece of evidence indicating crude migration from definite crude oil zone is given in a recent paper by J. Grant Spratt and Vernon Taylor, District Engineer, and Resident Engineer, respectively, of the Petroleum and Natural Gas Division of the Alberta Government, which was read before a meeting of the Canadian Institute of Mining and Metallurgy. These two authors point to the annual pressure tests which are taken by the government throughout the field. They point out that, if the size of the gas reservoir remains constant, there should be a decreasing amount of gas produced per unit pressure drop; but the annual tests have shown an increasing amount of gas produced per unit pressure drop during recent years, which indicates reduction in the size of naptha-gas reservoir by either oil or water encroachment.

With this cumulative evidence in view it was not long before a test well was undertaken. This was Turner Valley Royalties No. 1, which was spudded in some 12 miles south of Model No. 1 and well down the west flank. In June of 1936 it was completed at a depth of 6,828 ft., and blew in with a production of about 850 bbl. of 44 A.P.I. gravity crude and 2,000,000 cu. ft. of gas per day. This event started Turner Valley off on oil-boom No. 3. A little later, after Turner Valley Royalties No. 1 came in, the Foundation well, about 1½ miles south of the former, blew in with a substantial production. Then Sterling Pacific No. 3 was bottomed with a production of over 100 bbl. The B and B Royalties well entered the limestone at 6,195 ft. and came into production with a production of well over 1,000 bbl. a day, followed by Royalite-Sterling Pacific No. 4, which is producing over 1,000 bbl. per day.

Before conservation measures were brought into force waste gas was burned as in the above picture.

At the time this writer visited the field (late in April) about 25 wells were being drilled on the west flank, and some 36 more were scheduled to be spudded in during the spring and early summer.

Various estimates of the size of the productive area for crude have been made, and so far its length has been more or less proved to be at least 15 miles. It may be much more, and that part of the story will be told shortly because there are many wells being drilled, and projected far south of the present producers. Time alone can prove the width of the area. It is estimated to be not less than half a mile, and may be more. This indicates that there may be 5,000 acres on the west flank of Turner Valley where the limestone would be within drilling distance and on structure; but estimates of possible reserves can only become anywhere near reliable when more data are available than at present. An estimate of reserves is made in the paper previously referred to, and after allowing for various factors, it is placed at 50,000 bbl. per acre, which of course means 250,000,000 bbl. over the possible productive area. It is considered that a conservative estimate of recovery would be 25 percent, giving an ultimate production of at least 60,000,000 bbl. Such estimates, however, are only indicative of what may result from the present activity, and can in no case be considered an assessment of the ultimate value of the field. However, present indications are definitely encouraging, and Turner Valley may, quite easily, make oil history for Canada, and there is no doubt that, if the indications of to-day bear fruit, the whole foothills region will be carefully explored, and re-examined in a new light.

FORMULAE for Calculating Drill Pipe Collapse Point

Prepared by Engineering Staff, Mannesmannröhren—Werke, Düsseldorf, Germany

DEVELOPMENT in the engineering of deep-well drilling as noted during past decades permits penetration to very deep oil-bearing strata, and tubing thus sunk is claimed to have reached an approximate depth of as low as 3,500 meters (11,500 ft.). It is obvious that such a course of development has naturally directed attention to the vital importance of basing drilling work on scientific and empirical fundamentals.

Drilling operations must be watched with greater care at progressively increasing depths of the well, considering that in forcing the drill pipe downward the risk of failure becomes potentially greater.

A consideration of the factors bearing upon the success of deep-well drilling involves the need of discussing a theme already dealt with previously. It is the problem relating to the pressure which, being exerted by a water column surrounding the coupled drill pipe sections, causes collapse if inside the tube there is no water column of equal height. A pipe sustaining an external pressure uniformly distributed over its full peripheral surface is deformed into an oval cross-section. If this load reaches a definite height—namely the critical external pressure—the pipe will collapse.

The critical external pressure is easily determined, if the cross section under pressure is a theoretically true circle. The formula of calculation applied in the latter case is, however, unusable if there is even the slightest deviation from a perfectly true circle. As a matter of fact it is practically impossible to eliminate some ovality of the drill pipe within the limits imposed by present mill technique and equipment.

Since the resistance to the outside pressure decreases as the ovality of the tube increases, the formula as applied to the perfectly true circle would not give a correct result. Variation in wall-thickness should also be taken into consideration. In fact, it appears rather difficult to find a definite formula based on practical conditions. This is obvious from the numerous attempts to solve the problem theoretically.

All research work done with the object of determining the entire range of factors referred to above, and endeavours made to incorporate them in a handy reference formula have failed. The attempts produced results, which, at the best, are only approximate solutions. Reference is made in this connection to thorough investigations conducted by Dr. M. Geller.* A solution of the problem could only be arrived at by running practical tests.

The first experiments carried out along these lines were probably those conducted by Prof. R. J. Stewart, Pittsburgh, and published in the TRANSACTIONS OF THE A.S.M.E. under the title of "Collapsing Pressure of Bessemer Steel Lapwelded Tubes, 3 to 10 Inches in Diameter."

However, the empirically determined formulas of Prof. Stewart are only applicable to lap-welded tubes with a tensile strength of 48,000–60,000 pounds per square inch. Only in 1924 mention was made by Prof. Harold A. Thomas at a meeting of the American Petroleum Institute of two formulae, which can be used for seamless drill tubes, because these formulae consider the yield point of the material.

The Mannesmannröhren-Werke have long recognized the importance of this problem, and tests were started by them along these lines as far back as 1914. This research work, however, could not be finished and evaluated, having been interrupted by the Great War.

Large scale tests were started again in 1924 and a detailed report on the outcome of exhaustive investigations was published in a bulletin issued August 1926 ("Resistance of Mannesmann Seamless Steel Tubes to External Pressure of Fluids"). As a result of these tests, the following Formula I was ascertained for the collapse pressure, which, however, due to its empirical deduction, could only be applied to a material with a tensile strength ranging between 78,000 and 92,000 lbs sq. in.:

Formula I. $P_k = 107{,}600 \left(\frac{s}{D}\right)^2 + 626.2\left(\frac{s}{D}\right)$ in (metric) atmospheres

* "Der Bauingenieur," 1928, p. 828 u. 839, "Contribution to an Investigation of Tubes under External Pressure." "Die Röhrenindustrie," 1931, pp. 265, 281, 291; "Über den Widerstand gegen Aussendruck von Röhren mit ungleichmässiger Wandstärke."

This formula does not take the yield point of the material into consideration, and this fact appeared rather detrimental due to the increasing use of materials with higher strength properties. Investigations were continued for this reason and, realizing that conditions governing a tube under pressure above atmospheric are comparable with those prevailing when bars kink in being compressed, recognizing also that the distinguishing feature between the elastic range and yield phase as characterized by Euler (hyperbola) and Tetmayer (straight line) also holds true with regard to the external pressure problem, the possibility of revising the formula became apparent.

From tests conducted in 1924, the Mannesmannröhren-Werke arrived quite recently at two improved formulas relative to the critical external pressure range, and they examined their applicability by running extensive check tests. Of these Formulas II and III, the one giving the lower value should always be applied:

Formula II. $P_k = 2\,E\left(\frac{s}{D}\right)^3$ for the elastic range

Formula III. $P_k = \delta s\,(2.62\,\frac{s}{D} - 0.043)$ for the yielding range

In these formulas:

P_k = critical external pressure in (metric) atmospheres
E = modulus of elasticity 2.000.000 kg/cm²
s = thickness of wall in cm
D = outside diameter of the tube in cm
δs = yield point in kg/cm²

The accompanying diagrams (Figures 1 through 4), which have rendered good service in practice, will no doubt prove valuable in trying to trace the critical external pressure.

Some examples are stated below for the proper interpretation of the diagram.

1. If an 8⅝ in. API-Casing has an outside diameter D = 206.375 mm., a wall thickness s = 9.398 m/m, find the critical external pressure for a number of different materials.

   The ratio $\frac{s}{D}$, being decisive for the critical external pressure, will read in this case:

   $$\frac{s}{D} = \frac{0.9398 \text{ cm}}{20.6375 \text{ cm}} = 0.045$$

   If in Figure 1 a perpendicular is plotted at $\frac{s}{D} = 0.045$, the critical external pressure lies at those points, where this line inter-

sects those representing the various materials, i.e.

For a material with a yield point of 3,500 kg. per cm², the critical external pressure is 264 atm. Where the material has a yield point of 4,000 kg. per cm², the critical pressure is 302 atm. Where yield point is 4,500 kg. per cm², critical pressure is 339 atm., and where the yield point of the material is 5,000 kg. per cm², the critical external pressure is 364 atm.

2. Based upon a given depth of the well at a given specific gravity of the mud, the critical external pressure is fixed at 400 (metric) atmospheres.

What is the thickness of wall of a 5¾ in. API-Casing, if the material possesses a yield point of 50,000 lbs./sq. in.?

A horizontal line is drawn at $P_k = 400$ atmospheres right through to the mark line representing the material with the said yield point, and from here the curve is drawn downwards vertically and $\frac{s}{D}$ found to be 0.06; since D = 5¾ in. equal to 14.605 cm, s = 0.06x14.605 = 0.875 cm.

The examples outlined above can be calculated just as easily with the accompanying diagram shown in Figures 2–4.

Each graph includes an example, so that detailed instructions as to their applicability should not be necessary.

In order to establish the reliability of the two revised Formulas II and III, a series of tests were run by Mannesmannröhren.

Relationship between calculated critical external pressure and test result:

(a) 8⅝ in. API-Casing, 38 lbs./ft.
D = 219. 1 m/m
s = 10.8 m/m
Yield point of the material used for the experimental tube
$\delta s = 65.500$ lbs./sq.in.
Calculation: $P_k = 4{,}600\ (2{,}63\ \frac{1{,}08}{21{,}91} - 0{,}043) = 398$ at 375 atm.

(b) 6⅝ in. API-Casing, 28 lbs./ft.
D = 168.3 m/m
s = 10.6 m/m
Yield point of the material used for the experimental tube
$\delta s = 70.000$ lbs./sq.in.
Calculation: $P_k = 4{,}950\ (2{,}63\ \frac{1{,}06}{16{,}83} - 0{,}043) = 607$ at 620 atm.

A formula derived from empirical data will not correspond exactly to the test values obtained. However, the calculation although approximate will render satisfactory service for deep drilling inasmuch as the rating of the critical external pressure range is of much greater importance than its exact determination.

It will be readily granted that the solution described herein offers a most valuable means of eliminating dangerous factors of unreliability in deciding upon type and dimension of coupled drill pipe sections to be used under various conditions.

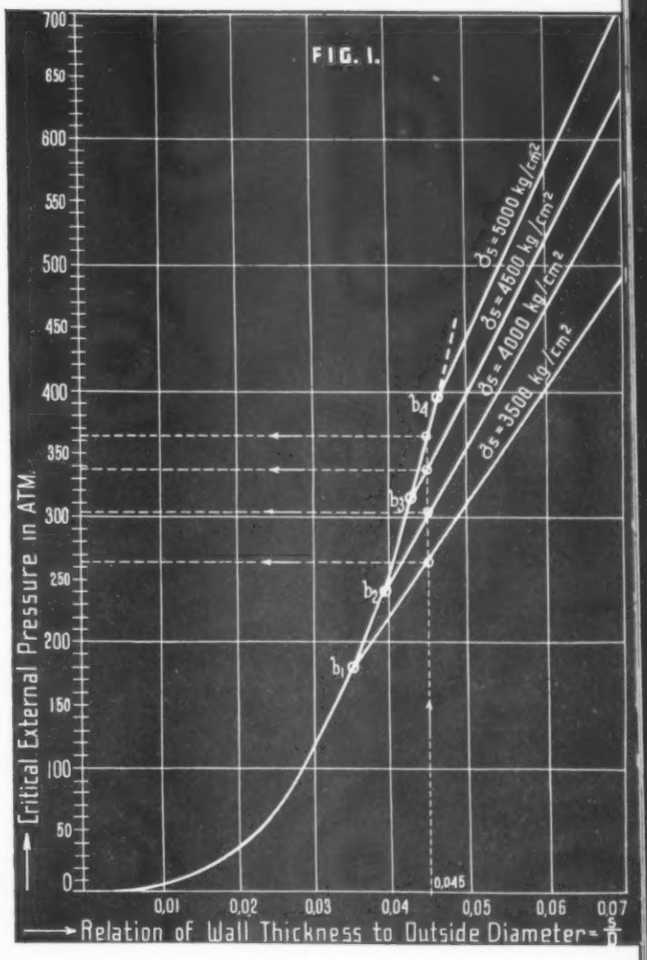


Fig. 2. Diagram relating to casing material with a yield point of 50,000 lbs. per sq. in. Fig. 3. yield point of 57,000 lbs. per sq. in. Fig. 4. yield point of 64,000 lbs. per sq. in.

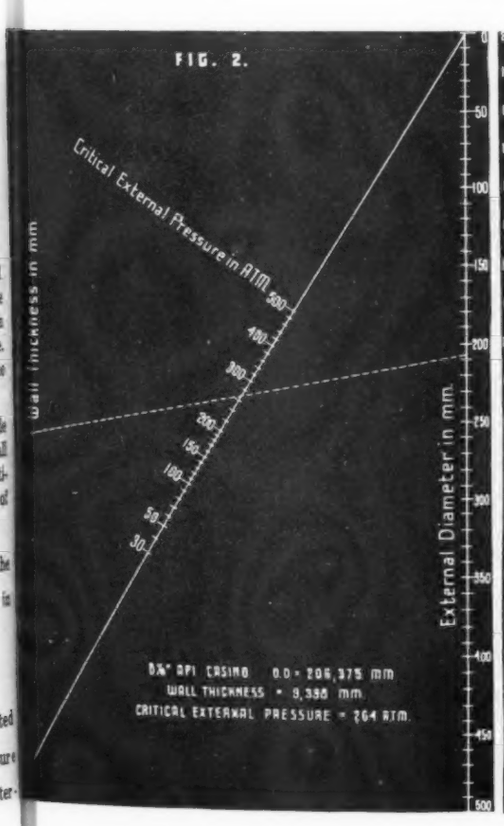


FIG. 2.
Critical External Pressure in ATM.
Wall Thickness in mm.
External Diameter in mm.
5¾" API CASING O.D. = 206,375 mm
WALL THICKNESS = 8,386 mm.
CRITICAL EXTERNAL PRESSURE = 264 ATM.

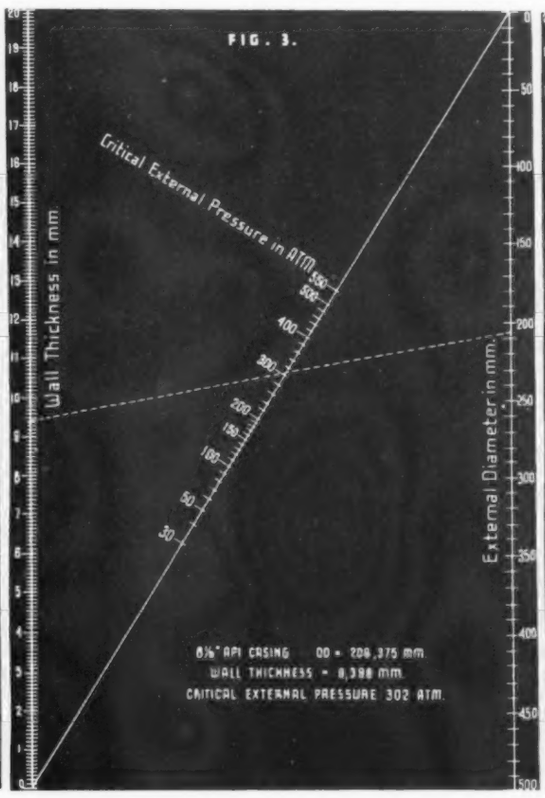


FIG. 3.
Critical External Pressure in ATM.
Wall Thickness in mm.
External Diameter in mm.
6⅝" API CASING OD = 206,375 mm
WALL THICKNESS = 8,386 mm.
CRITICAL EXTERNAL PRESSURE 302 ATM.

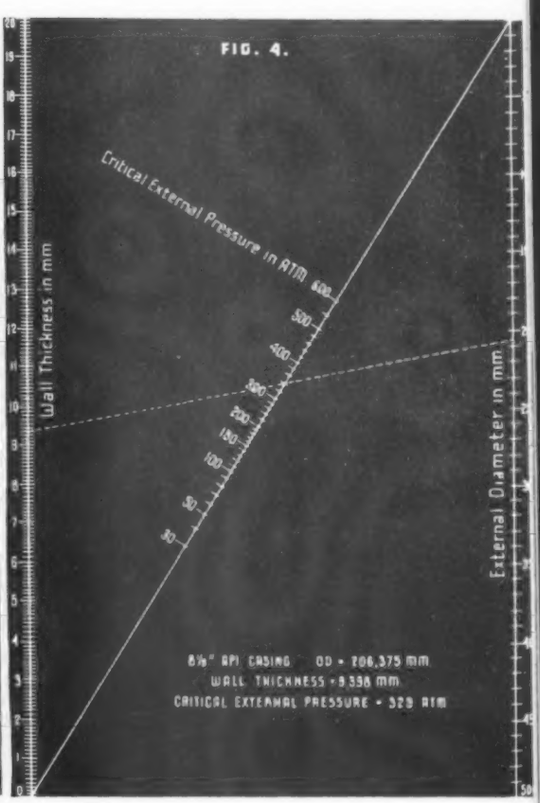


FIG. 4.
Critical External Pressure in ATM.
Wall Thickness in mm.
External Diameter in mm.
6⅝" API CASING OD = 206,375 mm
WALL THICKNESS = 8,386 mm.
CRITICAL EXTERNAL PRESSURE = 329 ATM.

PROGRESS in the Use of Alloy Steel
For Deep Drilling

CERTAIN objectives, that have always been considered desirable in drilling tools, have recently received greater emphasis as deep drilling has raised them from the class of desiderata to the status of essentials. Drilling tools are now called upon to resist not only greater tension, greater fatigue and greater tortional stresses, but also more frequent attacks of corrosive agents. While attempts have been made to meet these requirements by developing a carbon steel, it has been found that greater strength has only been achieved at the cost of lower ductility and less toughness.

Experiments were then carried on using molybdenum as an alloy in carbon steel. Comparing the results, it was found that the addition of 0.30–0.40 percent molybdenum to a steel containing 0.35–0.45 percent carbon, 0.60–0.80 percent manganese and 0.15–0.25 percent silicon gave a product with a yield point of 151,000 lbs. per sq. in. against 110,600 lbs. per sq. in. for S.A.E. 1040 steel. Yield point for the molybdenum alloy steel was 131,000 lbs. per sq. in. against 75,000 lbs. per sq. in. for the S.A.E. 1040. Reduction in area, however, was only 57.5 percent against 56 percent for the carbon steel and elongation was but 16 percent against 21 percent for carbon steel.

Addition of molybdenum to cast iron improves tensile strength, transverse strength, deflection, resilience and wear resistance.

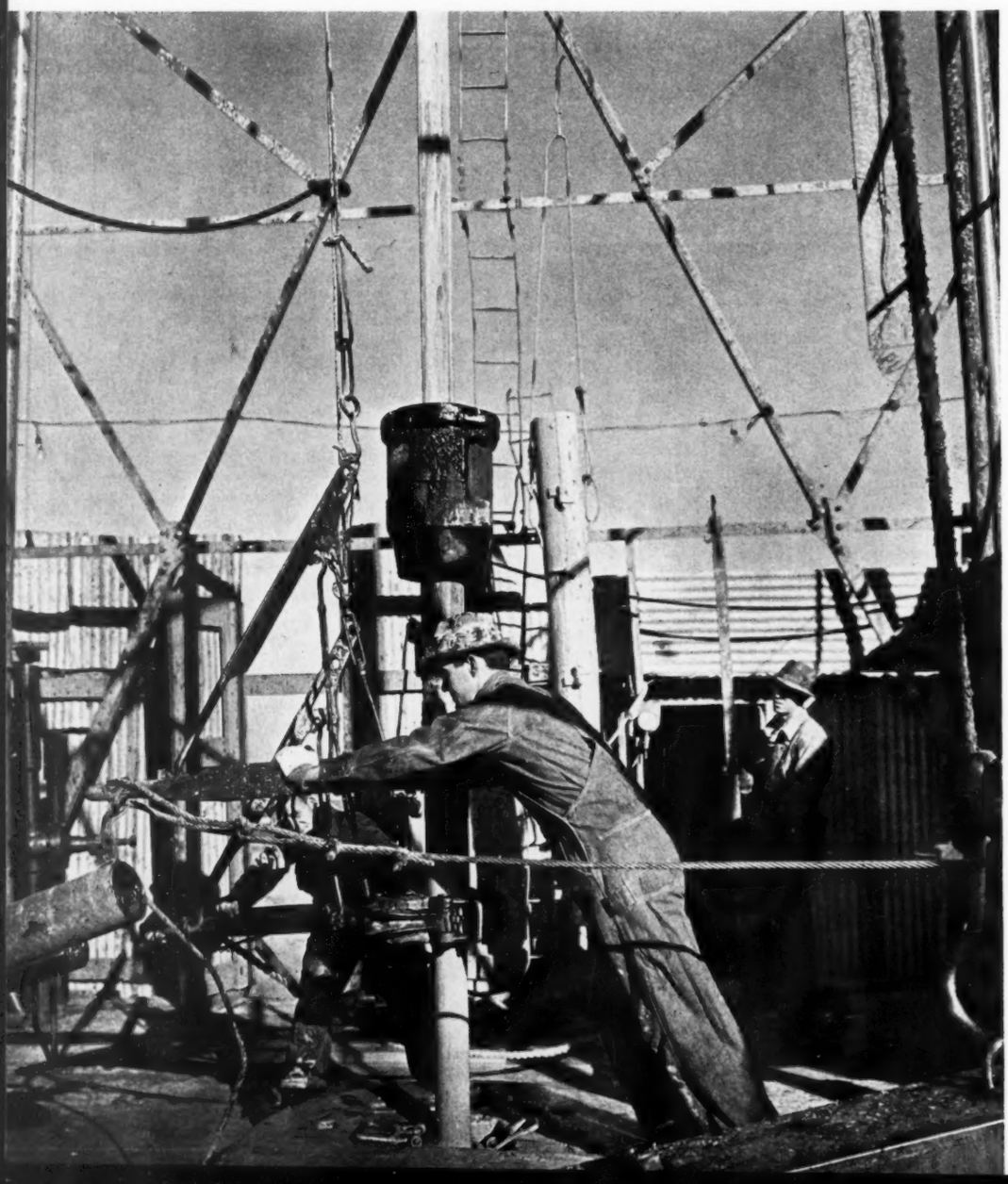
In the case of chromium steel, and chromium-molybdenum steel, the tensile strength of the latter is 141,900 lbs. per sq. in. against 115,450 lbs. per sq. in. for the former, where 0.27 percent molybdenum has been added to a steel containing 0.32 percent carbon, 0.72 percent manganese, and 0.80 percent chromium. The reduction in area in chromium-molybdenum steel is 65.2 percent and the elongation is 19.8 percent.

With the superior properties established by the tests of alloy steel, results of which are given very briefly above, it has been found desirable in a number of cases to use carbon-molybdenum cast steel for drag bits, and some of those now in service consist of 0.28–0.30 percent carbon, 0.60–0.80 percent manganese and 0.15–0.30 percent molybdenum. For particularly hard service, drag bits containing 0.25–0.35 percent carbon, 0.50–0.80 manganese, 0.50–0.80 chromium, 1.50–2.00 percent nickel and 0.20–0.40 percent molybdenum have been constructed and are now in use. For fish tail bits, improved welding characteristics and ease of heat treatment have been obtained by use of a steel consisting of 0.30–0.40 percent carbon, 0.80–1.10 percent silicon and 0.30–0.40 molybdenum.

Modern rock bit cutters and bridges have also been made in part of molybdenum alloy steel with improved results, particularly where the pins or bearings must have a high surface hardness.

The question of alloy steels for drill pipe has been repeatedly raised recently, due to the excessive waste involved in drill pipe failures as wells are drilled to greater depths. While an improvement in ordinary carbon steel can be effected by careful selection and careful heat treatment, a number of practical difficulties surround the problem of careful heat treatment of a 40 ft. length of drill pipe. Microscopic fractures may develop in the pipe during heat treating that will result in early failure. The solution for at least one manufacturer has been found in the use of a normalized and drawn manganese-molybdenum steel pipe containing 0.45 percent carbon, 1.50 percent manganese, a maximum of 0.25 silicon, 0.04 phosphorus, 0.04 sulphur and 0.20 molybdenum. The pipe is said to have physical properties in excess of A.P.I. Grade D specifications.

The whole subject of the use of alloy steels in drill pipe is of the utmost importance and is closely connected with the economic aspects of this problem. Can alloy steel be produced at a cost that represents an increase of less than the proportional increase in the life expectancy of the alloy steel pipe? Extensive research is being carried on to determine these facts and will be available in a later article to be published in WORLD PETROLEUM.



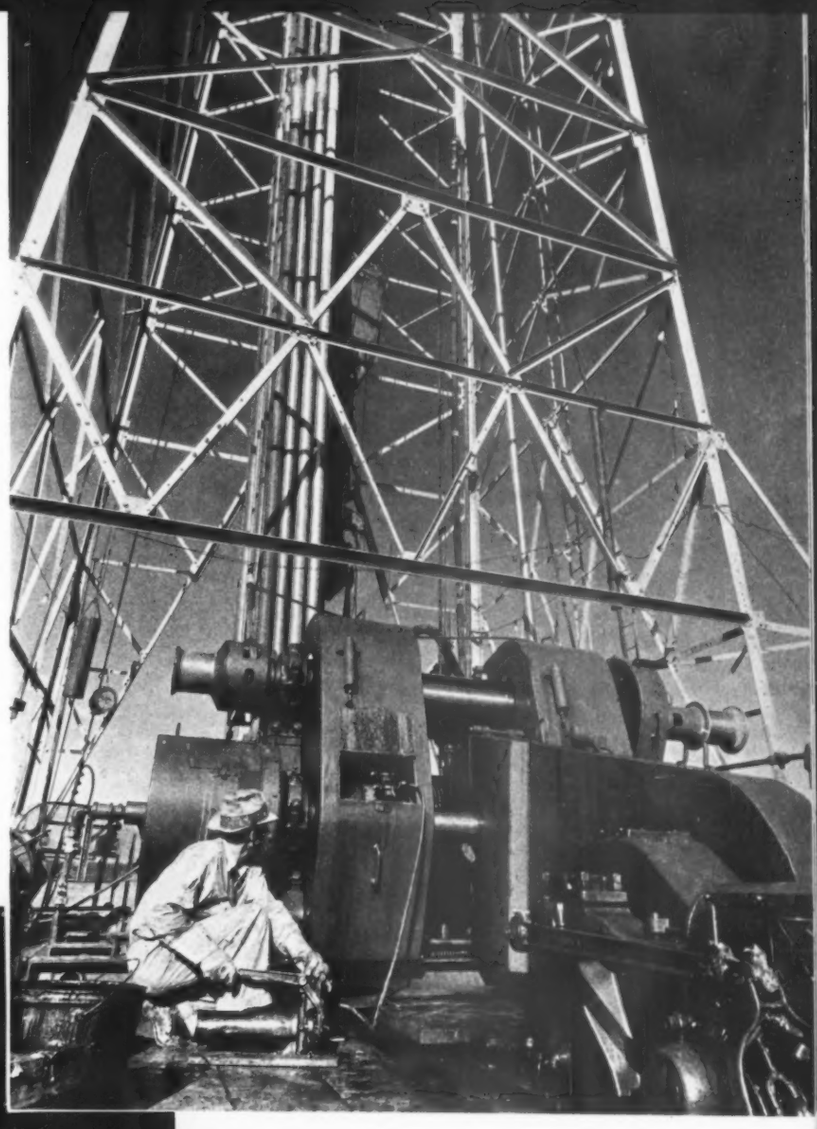
Tongs of cast nickel chrome-molybdenum in use on the derrick floor in Texas. Photograph, courtesy, Climax Molybdenum Company.

There is, however, nothing new in the use of alloy steels similar to some of those described above, for tool joints, drill collars and kellys. The use of improved alloy steels for this purpose has proved so satisfactory that their use will no doubt be continued until the entire drill pipe is made of alloy steels.

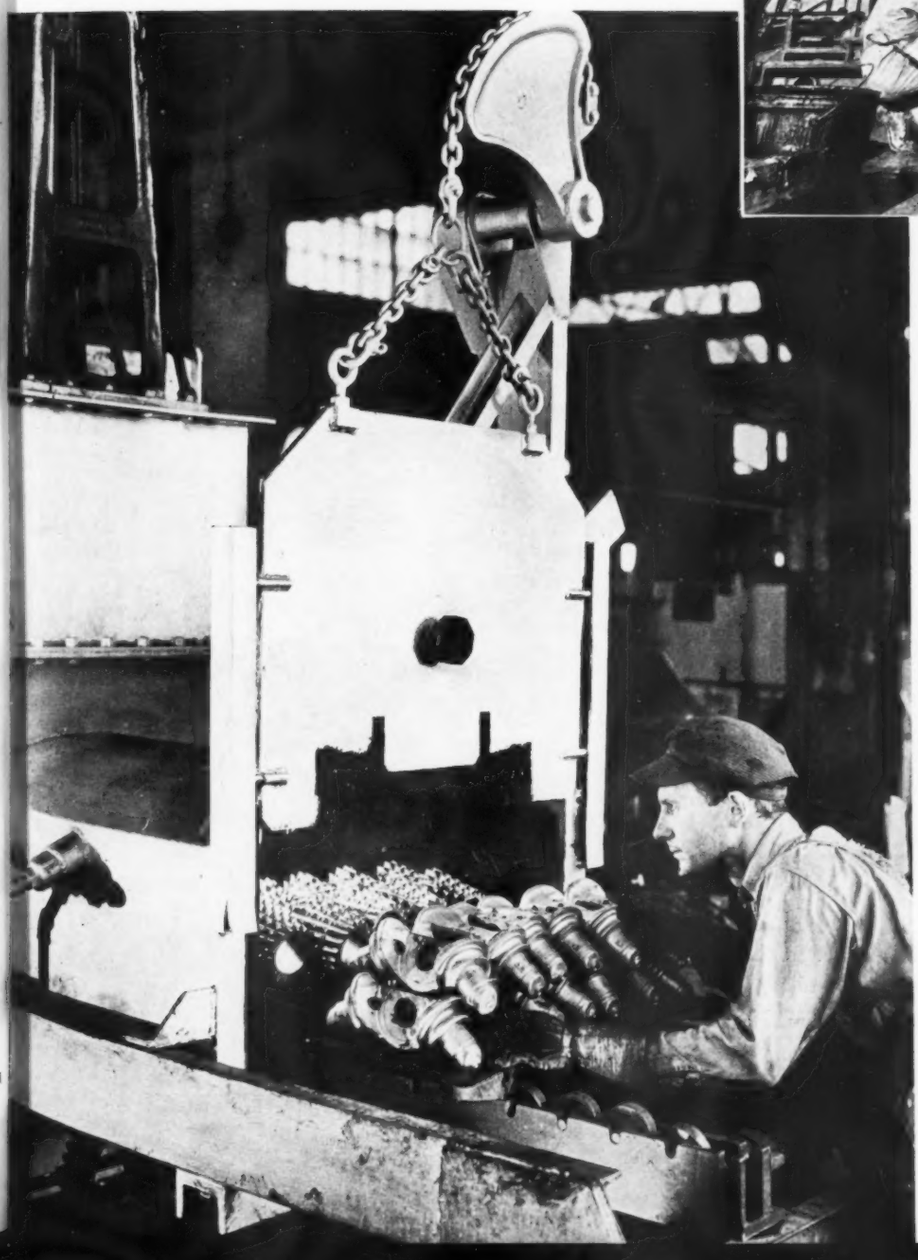
Slush pumps for deep well drilling encounter particularly hard service due to high pressures and abrasion from sand and mud. Liners have been adopted which render a satisfactory service and contain 3.10–3.30 percent carbon, 1.25–1.50 silicon, 0.75–1.25 nickel and 0.50 percent molybdenum. Another steel for liners in deep well pumps is composed of 3.10–3.30 carbon, 2.00–2.20 silicon and 0.35–0.50 percent molybdenum. Still another type steel for high pressure mud pumps is composed of 0.10–0.20 percent carbon, 0.40–0.70 percent manganese, 0.04 percent phosphorus (maximum), 0.05 percent sulphur (maximum), 1.50–2.00 percent nickel and 0.20–0.30 percent molybdenum.

Molybdenum steels are used for piston rods, valve bodies and seats as well as other parts of high pressure pumps.

Molybdenum alloy steel has also found



Powerful modern draw works with shafts built of S.A.E. 4140 to meet exceptional stresses. Photograph, courtesy, Climax Molybdenum Company.



Heat treating nickel chrome molybdenum rock bit cutters and bridges. Photograph, courtesy Climax Molybdenum Company.

increasing use in crown and traveling blocks in both pins and bearings where surface hardness is required to withstand wear that has increased enormously with the greater depths of recent wells. Ability of this material to withstand shocks resulting from the sudden loads developed in drilling is an important consideration. Parts of the power transmitting equipment that are subject to excessive wear have been made of molybdenum steel. Rotary chain links of S.A.E. 4140 resist distortion effectively, while pins and bushing subjected to abrasion, high shear and impact stresses have been successfully made of S.A.E. 4140 and 4615 (carburized steel). S.A.E. 4140 is also used for shafts in the draw works subject to exceptional tortional stresses and sudden impact stresses. Brake rim steel containing 0.30 percent carbon (maximum), 1.50–2.00 percent nickel, 0.55–0.75 percent manganese and 0.35–0.45 percent molybdenum helps to overcome heat checking and lengthen the effective life of brake rims.

The evolution of equipment suitable for the greater drilling depths that are presently required depends to some extent on changes in design; but fundamentally improved alloy steels must ultimately be brought within the economic range of possible return if adequate reserves are to be maintained by deeper drilling.

THEORY OF Combination Selective Cracking Demonstrated by Commercial Operations

By Eugene R. Smoley, Valentine Mekler, A. Henry Schutte
The Lummus Company

Condensed Version of a Paper Delivered at the Second World Petroleum Congress, Paris, June

THE work of the various investigators in the field of cracking has established certain principles which have directly contributed to the development of the modern selective cracking process. These are:

a. The selection of stocks according to comparatively narrow boiling range.
b. The separation of virgin and recycle stocks, or the segregation of stocks according to refractivity.

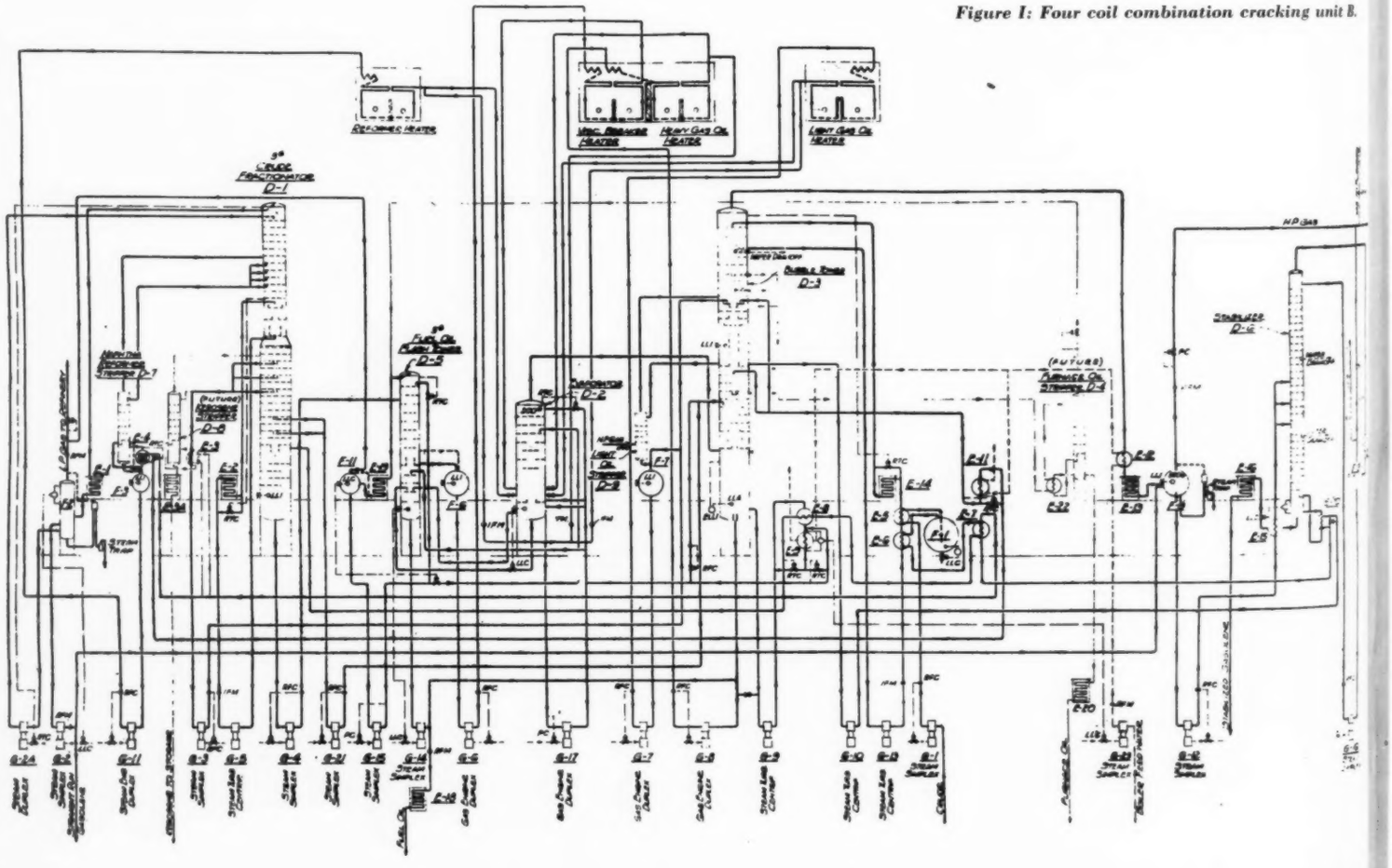
It has been shown that greater yield, higher octane gasoline, lower recycle ratio and longer runs are obtained when virgin and recycle stocks are cracked in separate coils rather than as a mixture in a single coil. This is also true when a combined cracking stock is segregated according to boiling range. When cracking the combined stock in one coil the operating temperature and pressure must be an average of the optimum conditions for each of the two stocks. Such a compromise results in operating conditions for the mixture which are too severe for the heavy fraction and too mild for the light fraction. Consequently, the heavy oil is over-cracked, forming coke, while the light oil is under-cracked and gives low octane number.

The value of segregating cracking stocks according to boiling range is a matter of common knowledge to the cracking operator. A relatively small percentage of heavier material added to the charge will limit the practical operating conditions to nearly those which would prevail for the heavier stock alone. The necessity for efficient boiling point separation of cracking stocks by fractionation is recognized by all designers but the number of streams segregated for selective cracking varies with the specific application.

Refractivity is a function of original source and degree of previous cracking. The benefits of segregating stocks according to refractivity are demonstrated by the work of Sachanen and Tilicheyev, Sydnor and Patterson, and Tarasov and Seledzniev, who show that recycle gas oil may be subjected to temperatures far higher than could be used for a virgin stock of the same boiling range. If these two stocks were cracked in a mixture the operating conditions would be limited by the coke forming tendency of the virgin material, and the recycle stock would be undercracked. By cracking the two stocks separately higher yields of higher octane gasoline, lower recycle ratios, and lower investment and operating costs result. This improved performance is obtained by operating each coil at high crack per pass, or volume percent gasoline yield on heater charge.

What is the maximum crack per pass for a given stock? What are the soaking time and the optimum conditions required for each coil of a combination selective cracking unit? There is little in the literature dealing with these questions. And yet, the designer must have this information before he makes his heat and material balance calculations. Past experience shows that the lighter the cracking stock the higher the allowable conversion per pass. The range of crack per pass, obtained in practice without excessive

Figure I: Four coil combination cracking unit B.



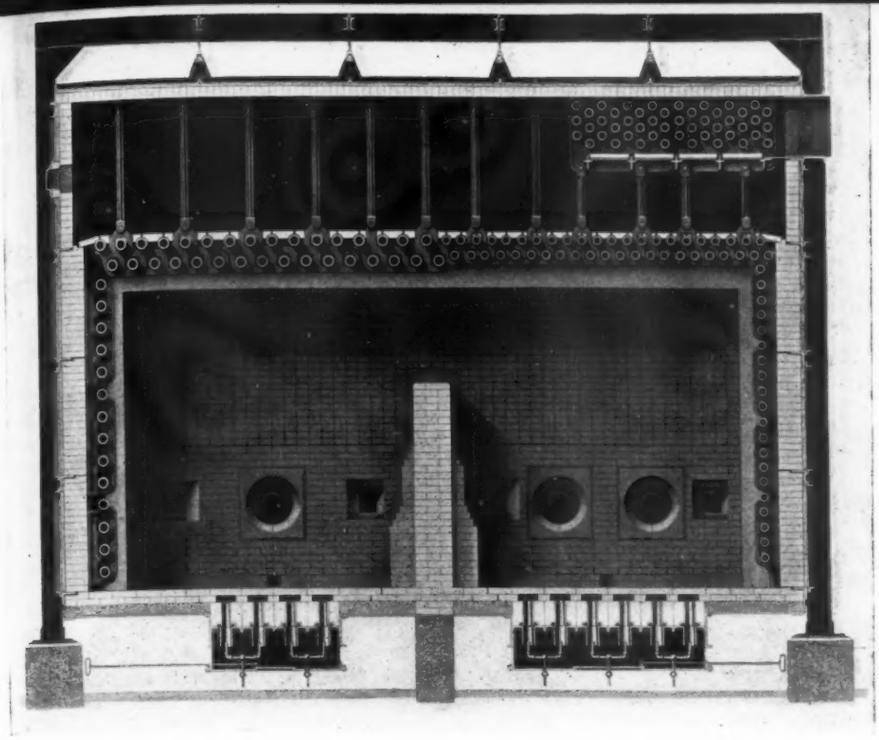


Figure V: Cross section of two stage heater.

coke formation varies with the cracking stock characteristics as follows:

Viscosity breaker stocks between 3 and 10 percent
Heavy virgin and heavy refractory stocks between 10 and 18
Light virgin and light refractory stocks between 14 and 30 percent

In order to obtain the desired crack per pass the stock must be subjected to a definite rate of cracking which is determined by the soaking time and temperature allowed in the heater. Before the introduction of cracking heaters with independently fired heating and soaking chambers, the time allowed for cracking was limited by the existing surface and the maximum transfer temperature which could be maintained without excessive coke formation. With these new type heaters the soaking time and temperature can be controlled to permit operation at optimum crack per pass for feed stocks of widely varying characteristics.

The ratio of total cracking heater feed to fresh cracking stock, or the overall combined feed ratio, is determined by the crack per pass obtained in the several heaters of a combination cracking unit. This ratio usually ranges between 2 to 1 and 4.5 to 1, depending on the character of the stock, the degree of selectivity and the method of processing. As a rule the heavier the fresh feed stock the higher the combined feed ratio.

The theoretical unit which would take advantage of selective cracking to the fullest extent is one where all stocks are separated according to both refractivity and boiling range. Practically, there is an economic limit to the number of selective coils which are used. It is the aim of this paper to present a description of some units which have novel features and which demonstrate the possibilities of combining the established principles of selective cracking which were outlined in the above paragraphs. Along with a flow diagram and the attendant description, plant data for various types of operation will be presented.

THREE COIL UNIT

The flow diagram in the original, not here reproduced, shows a three coil combination unit recently put in operation. This 14,000 bbl. per day unit processing East Texas crude includes one coil for viscosity breaking the reduced crude along with heavy cycle stock, operating at an outlet temperature of 880 deg. F. and 220 lbs. pressure. The second coil cracks gas oil and lighter recycle gas oil stock at an outlet temperature of 960 deg. F. and 500 lbs. pressure. The third coil may operate either for once-thru gas oil cracking with an outlet temperature of 960 deg. F. and a pressure of 750 lbs. or for once-thru reforming of heavy naphtha at an outlet temperature of 975–1,000 deg. F. and a pressure of 750 lbs. The reduced crude from the bottom of the crude flash tower picks up preheat and blends with the heavy cycle stock from the upper section of the fuel oil flash tower. The crude receives preheat from the quench and gas oil reflux streams and is finally passed through the convection section of one of the heaters for final flash temperature preheat before it enters the crude flash tower.

Because a kerosene cut had to be withdrawn from the crude tower, and there was a relatively small percentage of lower boiling virgin gas oil in the crude, the segregation of the stock into light and heavy gas oil would not be economical, and one gas oil coil was used. In order to keep the charging stock for this coil clean the boiling range of this mixture was narrowed by operating the evaporator and fuel oil flash tower so as to include the heavy ends in the viscosity breaker charge. As a result of a mild cracking in the viscosity breaker, the greater part of this heavy gas oil is converted into lighter and more refractory stock, which finds its way into the clean oil coil where it is cracked under more severe conditions without giving coking trouble.

FOUR COIL UNIT "A"

This is a four coil selective cracking unit now under construction. This 22,000 bbl. unit has one viscosity breaker coil operating at 890 deg. F. and 250 lbs. on reduced crude plus heavy recycle stock. One of the gas oil coils operates at an outlet temperature of 950 deg. F. and 260 lbs. pressure on virgin gas oil plus recycle from the viscosity breaker. The third coil is a recycle gas oil coil operating at 975 deg. F. and 750 lb. pressure. The reformer is the fourth coil, operating at 975–1,000 deg. F. and 750 lb. pressure.

The specific processing requirements in the case of this large unit made it advantageous to design a unit which would permit segregation of stocks with respect to both refractivity and boiling range. There is no virgin stock in the charge to the recycle oil heater and the cycle stock to the other gas oil coil has been but lightly cracked. Therefore the recycle coil charge can be cracked at more severe conditions than the other gas oil of this unit or the clean oil coil of the three coil unit. Instead of 960 deg. F. and 500 lbs. pressure, the recycle coil in this unit operates at a temperature of 975 deg. F. and a pressure of 750 lbs.

Two evaporators were used primarily because of the size of the unit. Market requirements demanded the separate stabilization of virgin and cracked gasolines and their withdrawal as separate streams. The resulting unit is one which gives a maximum yield-quality efficiency, and which permits an unusual degree of flexibility in product specifications.

FOUR COIL UNIT "B"

This unit (Fig. 1) has a vis breaker coil, two gas oil recycle coils operating on stocks of different boiling range, and a once-thru gas oil or reformer coil. This unit has operated on Michigan and Mid-Continent crudes and the plant operating data presented in Tables 1 to 4 are taken from three of the operations during a recent run.

OPERATION I: was on 36.9 deg. API Mid-Continent crude at a charge rate of 4,870 bbl. per day. The reformer heater was not used. The virgin gasoline overhead from the crude tower had an end point of 356 deg. F., 55 octane number and amounted to 26.8 percent on the crude. No virgin heavy naphtha or heavy virgin gas oil cuts were taken. The 477 end point light virgin gas oil, 16.2 percent on the crude, was pumped to the light oil heater charge accumulator. A 57 percent reduced crude was withdrawn from the crude tower bottom and sent to the upper section of the fuel oil flash tower above the vis breaker charge drawoff. During Operation I the fuel oil flash tower operated at atmospheric pressure, 725 deg. F. bottom temperature and a top temperature of 485 deg. F.

In the bubble tower the total material

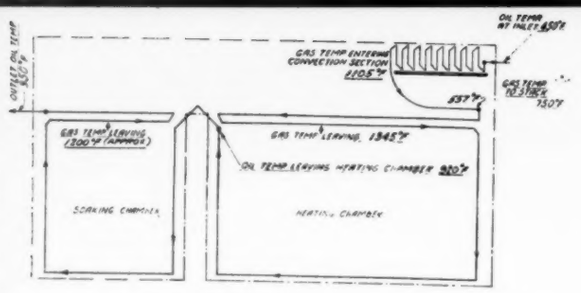


Figure II: Flow of oil through heaters in series.

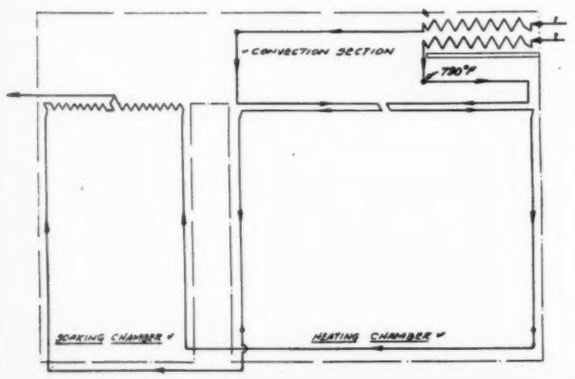
coming over from the evaporator at 212 lbs. per sq. in. pressure and 790 deg. F. was fractionated into gas and gasoline overhead, 20.5 deg. API bottoms for heavy oil heater charge and an intermediate cut of 30.2 deg. API gas oil for charge to the light oil heater. These stocks were separately cracked at 400 lbs., 925 deg. F. and 600 lbs., 980 deg. respectively. The vis breaker heater operated at 235 lbs. and 880 deg. F. outlet temperature. The bubble tower overhead was stabilized in a column forming an integral part of the unit to a 10.5 Reid vapor pressure final gasoline having a 390 deg. F. end point and an octane number of 66.0 by the C.F.R. motor method.

The overall yields obtained from Operation I were 68.3 vol. percent on the crude of stabilized gasoline, 25.2 percent of 9.2 deg. API fuel oil, and 6.5 percent gas.

OPERATION II: The reformer heater was put on stream as a once-through virgin gas oil cracker for Operation II. The 654 end point charge to this heater was a mixture of light virgin gas oil from the crude tower with fuel oil flash tower overhead. The cracking conditions for this stock were 750 lbs. pressure and 945 deg. F. heater outlet. The virgin gasoline cut was the same as that taken during Operation I. The light oil heater outlet was raised from 980 to 990 deg. F. and the heavy oil heater outlet from 925 to 930 deg. F., since more refractory stocks were being handled due to the greater percentage of recycled stock. In this way the crude charge rate to the unit was increased to 6,890 bbl. per day, as compared with 4,870 bbl. per day for Operation I. The viscosity breaker charge rate was increased from 4,580 to 5,500 bbl. per day. The data shows that the yields and the quality of the products were practically identical with those of Operation I.

OPERATION III: This third operation was on Michigan crude. When feeding this crude 7.3 percent of 64 octane number, 221 end point virgin gasoline was taken overhead on the crude tower. The reformer heater was operated for a 453 end point virgin heavy naphtha at 750 lbs. and 975 deg. F. The light oil heater operated at 600 lbs., 995 deg. F. and the conditions for the heavy oil heater were 400 lbs. and 925 deg. F. outlet temperature. Visbreaking was carried out at 235 lbs. and 880 deg. F., as for the two previous operations. In order to obtain the tar gravity reduction desired a pressure of one pound gauge was maintained on the fuel oil flash tower by means of a steam ejector jet attached to the overhead accumulator.

Figure III: Flow of oil through heaters in parallel streams.



Yields for this crude were 64.2 vol. percent of stabilized gasoline on the crude, 25.1 percent of fuel oil and 10.7 percent gas. The total stabilized gasoline was of 396 end point, 63 octane number and 9.6 Reid vapor pressure. The flashed fuel oil had a 9.6 deg. API gravity.

Aside from the separate cracking of light and heavy gas oil fractions, the most unusual feature of this unit is the design of the heaters. The high thermal efficiency of the heaters may be noted from Table 5.

There is no crude preheating section in the heaters of this unit. All of the preheat is obtained by heat exchange and, in addition, process steam is generated.

The fuel consumption for the three operations are covered in Table 6.

TABLE 1

Combination Selective Cracking Four Coil Unit "B"

Operating Data—Crude Inspections and Topping Operation

KEY:

Operation I —Cracking Mid-Continent Crude Reformer not in use.

Operation II —Cracking Mid-Continent Using Reformer Furnace for once-thru virgin gas oil cracking.

Operation III—Cracking Michigan Crude Reforming heavy virgin naphtha.

CRUDE INSPECTIONS	I	II	III
Crude	Mid-Continent	Mid-Continent	Michigan
Grav., °A.P.I.	36.9		39.9
I.B.P., °F.	116		126
5% @ °F.	163		188
37.5% @ °F.	450		....
Visc. @ 100°F., secs.	44		....
% S	0.46		....
B.S. & W., %	0.40		....
% @ 149°F.	3.5	Same as for Operation I	2.5
% @ 257	16.0		12.5
% @ 356	27.5		26.0
% @ 392	32.0		31.0
% @ 411	33.5		37.0
% @ 516	46.0		50.0
% @ 580	52.5		60.0
TOPPING OPERATION			
VIRGIN GASOLINE			
Vol. % on crude	26.8	26.0	7.3
E.P., °F.	356	350	221
O.N. CFR A.S.T.M.	55	56	64
Grav., °A.P.I.	64.2	64.6	82.3
R.V.P	10.5	10.5	16.5
HY. VIRGIN NAPHTHA			
Vol. % on crude	None	None	30.6
Grav., °A.P.I.			55.5
5% @ °F.			233
E.P. °F.			453
LT. VIRGIN GAS OIL			
Vol. % on crude	16.2	15.2	4.1
Grav., °A.P.I.	45.2	41.2	45.2
E.P., °F.	477	633	520
HY. VIRGIN GAS OIL			
Vol. % on crude	None	5.8	4.0
Grav., °A.P.I.	....	36.	40.6
E.P., °F.	....	....	608
Color, N.P.A.	....	1+	1+
REDUCED CRUDE			
Vol. % on crude	57.0	53.0	54.0
Grav., °A.P.I.	27.5	24.4	26.8

HEATERS

The heater is the heart of the cracking process. A brief summary will be given of the features which should be combined and co-ordinated in the cracking heater.

From the operating standpoint it is of primary importance that the heater be so designed that it is capable of long periods of uninterrupted operation. The length of run is usually dependent upon the rate of coke formation. Since the modern cracking plant represents a relatively high capital investment and since the mechanical work involved in a shutdown for cleaning out the unit is costly, a high service factor or total percentage time on stream is of great economic importance.

The conversion or cracking per pass obtained in the heaters of a combination cracking unit determines the combined feed ratio or, in other words, the quantity of material that must be pumped through the heaters per unit of fresh feed stock charge. The combined feed ratio in turn determines the size of the heaters, fractionating equipment, pumps and heat exchangers. It is therefore

TABLE 2

Combination Selective Cracking Four Coil Unit "B"

Operating Data—Crude Charge and Heater Data

KEY: Same as Table 1.

CRUDE	I	II	III
	Mid-Continent	Mid-Continent	Michigan
Crude Charge Rate, B/D	4870	6890	5766
VIS BREAKER HEATER			
Thruput, B/D	4580	5500	4160
Feed Grav., deg. A.P.I.	21.2	19.2	20.8
Inlet Temp., deg. F.	600	630	610
Outlet Temp., deg. F.	880	880	880
Outlet Press., lb./sq. in.	235	250	235
Heating Section Muffle Temp.	1475	1500	1440
Soaking Section Muffle Temp.	1450	1460	1390
HEAVY OIL HEATER			
Thruput, B/D	4330	4110	4010
Feed			
Grav., deg. A.P.I.	20.5	19.3	23.6
50% at deg. F.	542	555	563
90% at deg. F.	650	673	673
Color, N.P.A.	6	7	6
Inlet Temp., deg. F.	650	660	745
Outlet Temp., deg. F.	925	930	985
Outlet Press., lb./sq. in.	400	400	400
Heating Section Muffle Temp.	1470	1430	1390
Soaking Section Muffle Temp.	1415	1400	1360
LIGHT OIL HEATER			
Thruput, B/D	5870	5910	6030
Feed			
Grav., deg. A.P.I.	30.2	26.8	31.2
50% at deg. F.	445	....	454
90% at deg. F.	503	515	503
Color, N.P.A.	....	1	1+
Inlet Temp., deg. F.	630	560	530
Outlet Temp., deg. F.	980	990	995
Outlet Press. lb./sq. in.	600	600	600
Heating Section Muffle Temp.	1380	1440	1470
Soaking Section Muffle Temp.	1350	1420	1440
REFORMER OR ONCE-THRU VIRGIN G.O. HEATER			
Thruput, B/D		2010	1760
Feed			
Grav., deg. A.P.I.		38.8	55.5
50% at deg. F.		474	533
90% at deg. F.	Not in Use	602	616
E.P., deg. F.		654	653
Inlet Temp., deg. F.		345	260
Outlet Temp., deg. F.		945	973
Outlet Press., lb./sq. in.		750	750
Heating Section Muffle Temp.		1370	1365
Soaking Section Muffle Temp.		1300	1340

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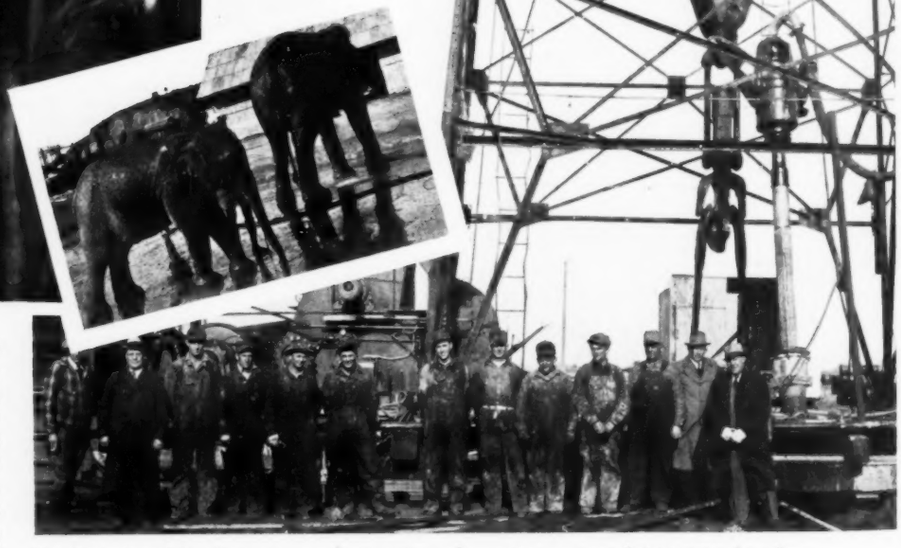

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essential that the heaters be designed for the maximum crack per pass that can be obtained without encountering coking difficulties.

Since there is only one combination of temperature, pressure and soaking time which will give the maximum crack per pass for a given stock charged the heater must be designed to permit altering these operating conditions within the range required by the specific application. These conditions can be met most satisfactorily by placing the preheating and soaking tubes of the heater in separate and independently fired chambers. Figure 2 shows a typical flow of oil through such a heater. The oil enters the convection section, then flows through the upper, lower, and side wall tube banks of the preheating chamber, and finally through the side wall, lower and upper tube banks of the soaking chamber. To insure the control of independent firing in each section a brick partition wall separates the heating and soaking sections. Figure 3 shows the flow of oil where two parallel streams are used. The flow through each parallel pass is maintained by independent controllers.

In order that a cracking heater may operate with a maximum freedom from coke formation and a satisfactory degree of temperature control in all parts of the preheating and soaking sections, it is necessary that the rate of heat transfer to the tubes be kept as uniform as possible throughout any given section of the surface. These conditions are obtained by a proper correlation between the flow of oil through the tubes, the flow of combustion products from the heating chamber and the disposition of tube surfaces. One method of handling the combustion products which has been very successful is to remove them over the entire area of the roof. In a heater of this type the upper row of roof tubes is covered by special baffle tiles (Figure 4) which gives a restricted clearance between the tube and the tile so that a high gas velocity over the surface of these tubes is secured. This makes the total transfer rates uniform for all tubes in the radiant section. The roof tiles form a series of orifices which distribute the flue gases evenly over the entire roof area. Upon leaving the roof tiles the combustion gases flow into a relatively deep plenum chamber, turn at right angles and pass over the convection surface. The arrangement of tubes in this surface is such that the flue gas temperature is reduced to a minimum before leaving the setting. Tests show the flue gas temperatures are approximately from 200–300 deg. F. higher than the temperature of the incoming oil, depending upon the service.

Uniformity of heat transfer in the radiant sections may be obtained by firing from both ends of the heater parallel to the tubes. The end walls where the burners are located are not covered with tubes and they therefore re-radiate heat to the end sections thereby equalizing absorption due to any increased temperature of combustion in the center of the heater. The excess air normally used in the heaters now in operation does not exceed 25 to 35 percent, while the CO_2 in the gases going to the stack has been as high as 12.4 percent by Orsat, when firing refinery gas. Flue gases analyses are shown in Table 5.

The heater wall should minimize heat losses to the outside, in order to permit high fuel efficiency. The wall construction should be as light as possible to permit supporting the heater above the ground so as to eliminate difficulties due to foundation settling. Fire brick is now available which weigh less than one-third as much as standard fire brick. It is also important that the refractory walls have a low heat storage capacity. Supporting the furnace floor above ground to eliminate heat flow in the foundation and enclosing the entire heater in steel walls effectively prevents air-infiltration and increases the efficiency of the heater.

The cross-section given in Figure 5 shows the construction of a heater having two separate chambers within the same setting, one for heating and one for soaking.

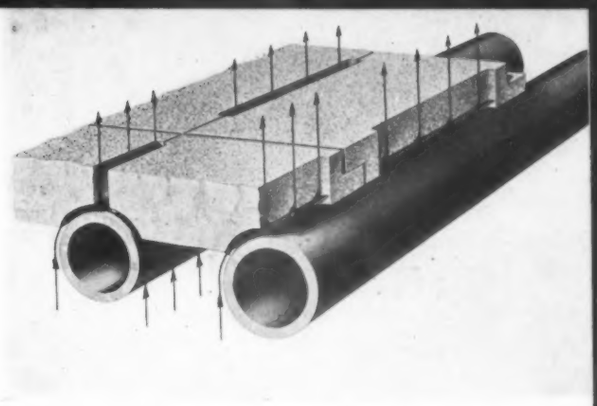

Figure IV: Diffusion baffle tile arrangement on upper row of roof tubes.

TABLE 3

Combination Selective Cracking Four Coil Unit "B"

Operating Data—Fractionating Equipment

KEY: Same as Table 1.

CRUDE	I	II	III
	Mid-Continent	Mid-Continent	Michigan
CRUDE TOWER			
Op. Pressure, #/sq. in.	5	5.5	7.5
Top Temp., °F.	260	265	150
Reformer Chg. Drawoff, °F.	...	...	290
Lt. G.O. Drawoff, °F.	370	395	450
Hy. G.O. Drawoff, °F.	...	...	492
Flash Zone, °F.	565	542	585
FUEL OIL FLASH TOWER			
Op. Pressure, #/sq. in.	0	5	1
Top Temp., °F.	485	525	495
Vis Breaker Chg. Drawoff, °F.	600	645	620
Bottom Temp., °F.	725	735	715
EVAPORATOR TOWER			
Op. Pressure, #/sq. in.	212	212	220
Top Temp., °F.	790	795	795
Flash Zone, °F.	830	840	835
Bottom Temp., °F.	820	827	825
BUBBLE TOWER			
Op. Pressure, #/sq. in.	209	209	215
Top Temp., °F.	430	420	425
Vapors Below Lt. G.O. Pan, °F.	690	685	685
Bottom Temp., °F.	750	740	745
Trap Tray Reflux out of Tower	440	470	435
Trap Tray Reflux to Tower	125	118	116
STABILIZER TOWER			
Op. Pressure, #/sq. in.	240	250	250
Top Temp., °F.	125	110	140
Feed Temp., °F.	320	322	290
Bottom Temp., °F.	410	405	395

TABLE 4

Combination Selective Cracking Four Coil Unit "B"

Operating Data—Overall Yields and Product Inspections

KEY: Same as Table 1.

CRUDE	I	II	III
	Mid-Continent	Mid-Continent	Michigan
Stabilized Gasoline, vol. % on crude	68.3	68.0	64.2
Fuel Oil	25.2	24.2	25.1
Gas plus Loss	6.5	7.8	10.7
STABILIZED GASOLINE			
O.N., CFR, A.S.T.M.	66.0	65.8	63.0
Grav., deg. A.P.I.	62.5	62.2	63.6
I.B.P., deg. F.	90	89	91
10% at deg. F.	124	123	118
50% at deg. F.	244	246	226
90% at deg. F.	356	357	352
E.P., deg. F.	390	392	396
Reid Vapor Pressure	10.5	10.7	9.6
Color, untreated, Saybolt	24	25	25
Gum, untreated, cu. dish, mg/100 cc.	9.0	9.4	9.5
FUEL OIL			
Grav., deg. A.P.I.	9.2	8.2	9.6
Vis., Furol at 122 deg. F.	230	278	75
B.S. & W.	0.4	0.4	0.3
Sediment, %	0.06	0.08	0.08
Pour, max.	30	35	15
Flash, P.M., deg. F.	230+	230+	230+

TABLE 5

Combination Selective Cracking Four Coil Unit "B"

Operating Data—Heaters

FLUE GASES

HEATERS	Analysis CO_2	Analysis O_2	Draft in Inches
Vis. Break. & Hy. Gas Oil			
North West	11.0	3.2	.26
North West Center	11.6	3.0	.33
South West	10.4	4.6	.33
South West Center	10.2	5.0	.32
LT. GAS OIL			
North West	12.0	2.0	.30
North West Center	12.2	1.8	.27
South West	11.2	3.6	.30
South West Center	12.4	1.8	.32
REFORMER			
North West	9.6	5.8	.22
North West Center	9.8	5.6	.22
South West	10.6	4.8	.22
South West Center	10.0	5.2	.22

TABLE 6

Combination Selective Cracking Four Coil Unit "B"

Operating Data—Fuel Consumption

KEY: Same as Table 1.

CRUDE	I	II	III
	Mid-Continent	Mid-Continent	Michigan
Equivalent Fuel to Heaters, as barrels 10 deg. API fuel oil per 100 barrels of crude *	6.45	6.35	7.15
Equivalent Fuel for Pumping, as barrels 10 deg. API fuel oil per 100 barrels of crude *	0.89	0.64	0.78
Lb./day of 125 lb. Steam Produced by Steam Generators	225,000	279,000	234,000
Steam consumed by Unit, Lb./day	322,000	373,000	434,000
Net Steam Consumed by Unit, Lb./day	97,000	94,000	100,000
Equivalent Fuel Entire Operation, Pumping and Heaters ** Vol. % on crude	7.3	6.4	8.0

* Fuel oil taken at a net heating value of 17,500 BTU/lb.

** Exclusive only of power for water pumping.

Foreign Oil Legion

ROBERT H. COLLEY has been elected president of The Atlantic Refining Company, to succeed W. M. IRISH who retired May 3rd. Mr. Colley, who entered the company's service in 1919, was elected assistant treasurer in 1926. He has been treasurer and a director since 1929, and was also a vice-president. E. H. BLUM, vice-president in charge of domestic crude oil producing, was elected to the board to fill Mr. Irish's place while PAUL SHUMAN, a former assistant treasurer, was elected treasurer, and ROBERT C. TUTTLE, in charge of transportation, and A. A. GARRABRANT, assistant manager of foreign sales, were elected vice-presidents.

ALEX H. DIEPENBROCK, chief petroleum engineer for Venezuela Gulf Oil Company at Maracaibo from 1926 to 1931, is now associated with The Petrol Corporation at Los Angeles, where he is serving in the same capacity.

C. T. BERRY, formerly drilling superintendent in Iraq and other Oriental fields, has been placed in charge of the drilling campaign of Anglo-American Oil Company Ltd., English subsidiary of Standard Oil Company of New Jersey. The first test site selected was in the Heathfield district, noted for its natural gas flows, and drilling was commenced during May.

JOE E. HUGHES, formerly resident engineer for Venezuela Gulf Oil Company at Cabimas and Lagunillas and well-known throughout Venezuela, is temporarily located in New York City at the Hotel Gregorian.

HOWARD F. ROUGH of California, territorial manager of the aviation division of Gulf Refining Company of Pittsburgh, has been appointed assistant director of the Bureau of Commerce. He joined the air commerce bureau in 1928.

FRANK REEVES and L. S. THOMPSON, geologists for Seaboard Oil Company, left New York late in April with a small geological party to conduct initial exploration work in Iran, over the concession recently obtained by the company's subsidiary, Amiranian Oil.

H. J. WHARTON, of Mene Grande Oil Corporation and formerly of Venezuela Gulf Oil Company at Maracaibo, recently spent ten days in Los Angeles, leaving for Seattle May 6th. He will return to Venezuela in the near future.

TOM BELL left Los Angeles recently to become drilling superintendent for Inyaminga Petroleum Company Ltd. to replace C. R. Smith, who is returning from Inyaminga, Portuguese East Africa, to California.

Robert H. Colley, new president of Atlantic Refining Company.

AMONGST those upon whom peerages were conferred by HIS MAJESTY KING GEORGE VI on the occasion of his coronation was SIR JOHN CADMAN, G.C.M.G., D.Sc., LL.D., who is widely known as the chairman of Anglo-Iranian Oil Company Ltd. and Iraq Petroleum Company Ltd., and who has amongst many and varied posts held those of government mining engineer in Trinidad, professor of mining at Birmingham University, and chairman of the Interallied Petroleum Council during the World War. He has also done much toward reconciling the coal and oil industries of the United Kingdom.

CAPTAIN J. W. FLANAGAN, president, Andean National Corporation, sailed from New York on the SANTA LUCIA for Colombia, May 7th, on a special mission as envoy of the Pan American Texas Exposition which will be opened at Dallas during July. The title of Ambassador Extraordinary for Foreign Participation and Honorary Director General was conferred upon Captain Flanagan and part of his time in Colombia will be devoted to obtaining the participation of Colombia in the Exposition. Captain Flanagan expects to interest a number of Colombian athletes in competing with the representatives of other South American countries at the Exposition.

Captain J. W. Flanagan, president of Andean National Corporation, being appointed Honorary Director General for Foreign Participation of the Pan-American Texas Exposition. Left to right: Roy Miller, congressman Albert Thomas, Captain Flanagan, house speaker Sam Rayburn, vice-president John Garner, senator Morris Sheppard, and senator Tom Connally.

Sir John Cadman, G.C.M.G., D.Sc., LL.D., chairman Anglo-Iranian Oil Company Ltd., from the portrait in oils by John A. A. Berrie.

GEORGE E. PUTNAM, one of the three American drillers employed by Iraq Petroleum Company, Ltd., and who has been associated with the development of Iraq oilfields for the past seven or eight years, is on leave in California, having driven by car across the continent.

C. E. NORDBLOM, of Burmah Oil Company Ltd. at Yenangyaung, left San Francisco to return to Upper Burma on board the PRESIDENT COOLIDGE, May 10th.

S. L. SLAUGHTER, drilling superintendent of International Petroleum Company at Talara, Peru, recently arrived in the United States and is visiting Oklahoma and California.

A. W. SIMMONS, drilling superintendent for Sabalo Transportation Company at Tampico, Mexico, is visiting his ranch in Mendocino County, Southern California.

W. E. JACKSON, of the drilling department of Caribbean Petroleum Company at Mene Grande, returned to Venezuela early in May after spending several months in the United States on vacation.

MRS. N. J. ALLEMAN sailed on the PRESIDENT HAYS, May 20th, to join her husband who is in charge of drilling a wildcat for Attock Oil Company, Ltd., about 150 miles from Khaur, Punjab, on the northern frontier of India. This well is being drilled under an armed guard of soldiers, and Mr. Alleman is the only foreigner within a hundred miles of the location.

SIR THOMAS INSKIP, Minister of Defence for Great Britain, will be guest of honor during the inaugural ceremony in connection with the spudding in of the first test well of Anglo-American Oil Company Ltd. about June 1.

EDWARD L. BATEMAN, chairman of Inyaminga Petroleum Company, Ltd., left New York May 12th on the AQUITANIA after travelling throughout the United States on company business. Mr. Bateman's company is engaged in drilling tests in Portuguese East Africa in an endeavour to prove the existence of commercial supplies of oil.

A. ALLEN WEYMOUTH, geologist and petroleum engineer for Bahrein Petroleum Company, Ltd., and C. A. RODSTROM, chief production clerk, recently bought autos in New York and drove to California on leave.

M. T. HALBOUTY, of Houston, Texas, became associated with the newly-formed Merit Oil Corporation on May 1st, 1937. This company, located in the Shell Building, will be interested in drilling and leasing, etc.

Norman Dorn, who was recently appointed manager of Alexander Anderson, Inc.

HARRY D. HUSKEY, head driller of Iraq Petroleum Company, Ltd., is expected to arrive in New York on leave early in June.

JOE E. SITLER, assistant purchasing agent for Standard Oil Co. of New Jersey, and B. A. WARREN, buyer for Standard Oil's purchasing department, returned late in April from a month's trip through the properties of Lago Petroleum Company and Standard Oil Company of Venezuela.

BEN BECK, assistant stores superintendent for Caribbean Petroleum Company arrived in New York on leave last month.

G. A. FRITTS, recently resigned from his position of store keeper for Caribbean Petroleum Company at Mene Grande. He passed through New York in April with J. R. DUNN, and L. E. DUSTIN, both of Venezuelan Oil Concessions, Ltd., on his way to California.

DR. C. W. CORBETT, who spent a few months in England last year for Gulf Oil Corporation, returns to conduct geological work for Gulf Exploration Company (Great Britain) Ltd. early in June. He is to be followed in July by a party of geophysicists, who will carry out the necessary graviometric and seismographic work.

WILLIAM R. HEROD, executive vice-president of International General Electric Company, returned to the United States from Europe late in April aboard the MANHATTAN.

RED FULLERTON, chief gauger for Venezuela Gulf Oil Company at Lagunillas, is home on leave. He passed through New York early in May, where he purchased a car and drove on to Louisiana.

W. T. DINKINS was recently appointed general sales manager of Richfield Oil Corporation to fill the vacancy caused by resignation of R. W. WALSH, who recently left the company to return to the east where his personal affairs require his full attention. Born in Chicago in 1888, Mr. Dinkins attended the North Carolina State University and then joined the Waters Pierce Oil Company as manager for Oklahoma. Gassed and wounded in overseas service in the World War, he was ultimately commissioned a captain, and returned to America in 1919 as assistant to the general sales manager of Sinclair Consolidated Oil Company in Chicago. Then followed various transfers all over the mid-west, and later to New York as manager of the eastern district. Five years later he was appointed assistant to the vice-president. He also assumed operation of the Pierce Petroleum properties in the south and southwest when taken over by Consolidated. For the past five years he has been in Fort Worth as manager of the southwest district of the combined operations of the Pierce and Sinclair companies, which post he recently vacated to join Richfield.

W. T. Dinkins.

HELIUM PRODUCTION CONFINED TO

United States as Only Commercial Producer

Other Nations Have Potential Resources but Have Done Little to Develop Them—U. S. Committee Recently Organized to Consider Supplying Other Countries

COMPLETE destruction by fire of the airship Hindenburg, a hydrogen-filled dirigible, at the finish of its first crossing from Germany of the 1937 season revives interest in the subject of helium versus hydrogen as a means of floating lighter-than-air craft. The disasters which befell those ill-fated airships in American service, the Shenandoah, Akron, and Macon, were caused by structural defects. Significantly, none of them exploded or burned—all having been filled with helium, inert and non-inflammable gas —only hydrogen-filled bags having met their end by fire.

Apart from the most important factor of non-flammability, helium is not as liable to loss as is hydrogen because when it is diluted by air it may be drawn from the gas cells, purified for 50 cents to $1.50 per 1,000 cubic feet, and used again, although it is still subject to some wastage. This tends to make the ultimate cost of the two lifting media more comparable. The initial cost of hydrogen produced for airship operation is less than that of helium, but constant diffusion of air into the gas cells and of buoyant gas from the cells into the surrounding atmosphere gradually lowers the lifting power of the gas and makes it necessary to re-inflate the ship, for there is no known process for its safe and economical purification in such volumes.

Accusations have been leveled against the United States for its "dog in the manger" attitude with regard to the export of helium. The American government has at no time intended to make impossible the use of helium for inflation of foreign passenger dirigibles. Congress did promulgate the Helium Act a number of years ago, placing restrictions upon the export of helium and requiring the assent of a board composed of the Secretaries of Commerce (succeeded by the secretary of the Department of Interior when the Bureau of Mines was transferred to that Department), Navy and War—with the approval of the President—for sale of helium abroad. This was a wholly natural precaution to prevent the possible use of helium in warfare jeopardizing the neutral status of the United States. Although during the Hoover administration Dr. Eckener was informed that the inert gas would be made available to his company, if desired, he was not receptive to the idea on the grounds that it was expensive and greatly reduced the payload and there is no record of any application for helium ever having been made by his interests. The American export policy with regard to this valuable gas has been to make it available for commercial use of countries abroad provided that there was no intention of using it for war purposes. The only occasion when it was necessary to deny an export application was because insufficient guarantee was given that it would not be used for such purposes, as required by law.

Inasmuch as the government is forbidden to sell helium to private industry—although it may be leased—the aforementioned regulation had been under fire for some months prior to the Hindenburg disaster. In January of this year there was agitation for permission to buy the gas from the government plant, particularly by the medical profession, and in April the Military Affairs Committee of the House held hearings on amending the Helium Act to enable sale or lease of the gas to American citizens and corporations for scientific and other purposes; also to liberalize the procedure for making export shipments of quantities not suitable for airship operation.

On May 19, following the Hindenburg disaster, it was announced in Washington that the President had appointed a committee of five Cabinet members to formulate policy in regard to releasing helium to other countries. This committee was prepared to confer with Dr. Eckener on his arrival in Washington where he was expected to go on completion of the investigation of the Lakehurst tragedy.

There is no important commercial production of helium outside the United States. Other governments interested in the promotion of lighter-than-air craft have not, to date, indicated a desire to buy or lease the inert gas from America. The United States government itself initiated the present industry during the World War by building experimental plants and fostering their development. Possibilities of helium production sprang into light first in April, 1917. G. A. Burrell, Dr. R. B. Moore and other officials of the Bureau of Mines, with the approval of the Director, promoted an investigation as to the feasibility of large-scale helium separation from natural gas for military and naval aeronautics. Eventually these activities resulted in an allotment of funds from Army and Navy appropriations to undertake an experimental helium production program and the Bureau of Mines was authorized to conduct the technical work.

Three private firms co-operated with the government in this work and three plants were set up, producing about 200,000 cubic feet of helium in their experimental runs, of which 147,000 cubic feet compressed in steel cylinders was awaiting shipment on the dock at New Orleans for inflating observation balloons in France when the Armistice was signed. Linde Air Products Company was the most successful of the private companies, drawing on its experience in manufacture of liquid air, and the process used was analogous to cycles already used for separating oxygen and nitrogen from the air by fractional distillation at low temperatures.

After serving their pioneering purpose, the experimental plants were abandoned, and in 1919 arrangements were made for a large production plant to be constructed and operated by Linde under supervision of the joint Army and Navy Helium Board. At a cost of some $5,000,000 a reduction plant was erected at Fort Worth, Texas, and a ninety-mile pipeline laid from the Petrolia field. The Petrolia gas had a helium content of about one percent, of which only 50 percent was recoverable by the methods employed, and its purity when processed was only about 90 percent. For almost a decade after its opening in 1921 the helium plant was in operation, and was only placed on an inoperative status because of the exhaustion of the Petrolia gas field. It was no sooner realized that production was not keeping up with the demands of the Army and Navy than the Bureau of Mines began its search for a new supply of helium-bearing gas. Two sources were discovered, one in Montague County, Texas, known as the Nocona gas field, and the other in the Cliffside structure of Amarillo gas field in Potter County, of the same state.

In the meantime the helium output of the Fort Worth plant was being eked out by production from the plants of Kentucky Oxygen-Hydrogen Company at Dexter, Kansas (where the gas had first been discovered in America), and at Thatcher, Colorado, under government contract. An improved liquefier was also installed at Fort Worth.

The gas of the Cliffside structure is approximately twice as rich in helium as that from the Petrolia field, and government control has assured its conservation by obtaining leases and extraction rights over 50,000 acres of virgin territory. This structure, richest known source of helium, is believed capable of supplying the world consumption for over 175 years. The gas from this field contains nearly two percent of helium, under

such pressure that there is no need for further compression in the process of extraction, and the plant erected at Soncy, seven miles from Amarillo, has been successfully operated for some eight years by the Bureau of Mines.

The Fort Worth plant was dismantled in January, 1929, and in April of the same year the Amarillo production commenced. Such was the success of the plant that a new unit was added the following year and purchase of gas rights increased. The cost of the whole project, inclusive of plant and gas rights, was about half that of the original installation at Fort Worth, being about $2,200,000, and the annual capacity was 24,000,000 cubic feet, or greatly in excess of peace-time requirements. During 1935, the Amarillo plant operated to supply all the helium—10,218,480 cubic feet—used by the Army and Navy in aeronautics. From initial operations in May, 1929, to June 30th, 1935, the plant produced 68,687,620 cubic feet at an expenditure of $796,626.16 for plant and gas field operation, making an all-time average gross operating cost of $11.58 per thousand cubic feet of helium for that plant. The sale of residue gas returned $188,228.83 to the national treasury over this period, making a net government expenditure of $607,397.33, or $8.84 per thousand cubic feet produced.

At the outbreak of the War helium had been produced in the laboratory at a cost of $1,600 per cubic foot. This was reduced to a tremendous degree when the Fort Worth plant nitially commenced to turn it out for $500 per thousand cubic feet in 1921. By 1925 the cost had been cut to $36 per thousand cubic feet, and by 1932 to $7.10 per thousand cubic feet for gas that was 98 percent pure. The success of the Bureau of Mines was so great as to cause a virtual cessation of private enterprise, except for experimental purposes, and officials of the Amarillo plant were able to prove on one occasion when demanded that their expenses were less by at least $10 per thousand cubic feet than the private firm that supplied helium to the Navy on contract.

The principle employed is the same as that used at Fort Worth, although many modifications of detail have been made. There are four wells used in rotation which furnish gas to the plant through a six-inch welded steel pipe about 12 miles in length. The natural gas which the plant processes has one-half percent carbon-dioxide content which must be removed before the helium can be separated.

First step of the removal is accomplished by scrubbing the gas under pressure with a six percent solution of caustic soda inside a four-inch pipe about 1,000 ft. long, through which all the incoming gas to the plant must pass. The solution is forced into the gas stream with the aid of a plunger-type pump, after which the gas and liquid are separated in a special trap, where the solution is automatically removed and returned to low-pressure storage tanks.

When the liquid solution is spent it is recausticized by the use of lime, the resulting solid calcium carbonate removed by a mechanical thickener, and the solution again returned to a storage tank.

The gas, still under pressure, is then conveyed to the nearby building where the helium is actually removed. The gas coming to the separation building consists chiefly of methane, ethane, nitrogen, and less than two percent helium. To separate the helium to a nearly pure state the mixture must be cooled to a temperature of about 300 deg. below zero. The released helium is then brought to atmospheric temperature through heat exchangers which cool the incoming gas. The complete operation from atmospheric temperature to minus 300 deg. and back to atmospheric temperature takes less than one minute.

During the process a small amount of nitrogen is also removed from the mixed gases and sent to a gas holder to be used in a refrigeration cycle. It is first compressed to about 500 lb. per sq. in.:—after heat of compression is removed it is expanded to atmospheric pressure and returned through heat exchangers to the gas holder. The engine, by means of an electric generator, removes the energy from gas, and the cold exhaust cools the nitrogen entering the engine. In this manner the system is cooled progressively until the exhaust of the engine is sufficiently cold for the purpose.

This nitrogen cycle is kept entirely separate from the natural gas circulation and compensates for a portion of the heat losses in the system. It also furnishes the necessary low temperature to bring the helium to the desired purity.

Helium thus produced has a purity from 40 to 80 percent, depending on the method of operation, although it is possible at this stage to produce helium of a higher purity.

The gas is now ready for the final operation. Accordingly, it is sent to a gas holder and from there recompressed, carefully dried over lump caustic soda, and sent through another similar cycle by which its purity is stepped up to approximately 98 percent.

Helium is shipped from the plant to the Army and Navy flying fields either in tank cars—consisting of three or more large heavy-walled seamless steel tanks—or in small cylinders. The former are filled at a pressure of 2,000 lb. per sq. in. and hold about 200,000 cubic feet of free gas in a compressed state, while the latter are shipped under a pressure of 1,800 lb. per sq. in. and hold about 178 cubic feet.

Besides its principal rôle in lifting lighter-than-air craft, helium has been used in connection with caisson work, shaft sinking and tunneling as a preventative of the "bends"—ailment of those who work under high pressures. It is possible that uses for helium may be found in metallurgical processes by reason of its inertness and of its comparative insolubility in metals, either molten or otherwise.

In certain medical and surgical applications also, which are now in the experimental stage, interesting and significant results are indicated in the practical use of helium. Other possibilities are as a preservative for food; in connection with refrigeration processes; for filling electric light bulbs; for cooling electric motors; and for fire-proofing high-tension switch boxes.

While it is practically a commercial monopoly the United States government's control of helium production is not absolute, and other nations have potential supplies of the gas, only they have done little or nothing to develop them.

During the World War helium was discovered in the Canadian natural gas fields and about 60,000 cubic feet of the gas, from 60 to 90 percent pure, was extracted. A later Dominion survey, in 1926, indicated that Canada could produce 2,000,000 cubic feet of helium, at least, per annum. Discovery of helium occurrence was made in Trinidad in 1932 at Longdenville, 18 miles east from Port-au-Spain. Russia is reported to have large resources of helium and is now building a reduction plant for its manufacture, while smaller amounts have been reported in the Belgian Congo, Brazil, France, and Sweden. India and Brazil are also capable of producing helium from their monazite sand deposits, but the percentage is stated to be about 20 parts in 1,000,000,000, making its production on any scale out of the question. The Reich Geological Institute claims to have produced helium from natural gas borings on Luneburger Heath, and from gas wells near Hamburg, and it is not unlikely that there are occurences elsewhere in the world that as yet have not been recorded.

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SOVIET MARKETING ORGANIZATIONS SOLD TO GULF

B. P. NEWTON, vice president, Gulf Oil Corporation, in charge of foreign marketing, who recently returned from his business trip to Europe during which he visited Moscow, announced today a renewal of supply agreements by their British, Belgian and Scandinavian subsidiary companies with Soyusnefteexport. In addition, Mr. Newton announced acquisition of the entire marketing organization of the Soviets in Sweden and Finland. Mr. Newton states that as a result of his visit to Moscow he was much impressed by improved conditions there as compared to his previous visit nearly four years ago.

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BRITISH IMPORTS FIRST FOUR MONTHS

British Oil Imports By Products

(Barrels)

	April	Four months to April 30, 1937	Four months to April 30, 1936
Kerosene	464,000	2,015,000	2,097,000
Motor spirit	3,859,000	12,629,000	12,183,000
Lubricating oil	278,000	825,000	1,205,000
Gas oil	337,000	1,187,000	1,232,000
Fuel oil	1,609,000	6,431,000	5,403,000
Other sorts	2,000	110,000	177,000
Total refined products	6,549,000	23,197,000	22,297,000
Crude	1,272,000	4,270,000	4,368,000
Total imports	7,821,000	27,467,000	26,665,000

WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing With Technical and Economic Aspects of the Industry. ***Edited by Dr. O. W. Willcox***

PETROLEUM GEOLOGY

THE SPINDLETOP OIL FIELD, JEFFERSON COUNTY, TEXAS.—J. Brian Eby and Michel T. Halbouty, in BULL. AM. ASSOC. PETROLEUM GEOLOGISTS, vol. 21 (1937), No. 4, pp. 475–490.

Major oil production at Spindletop now comes from the south, southwest, and west flanks of the dome. Oil is found in the Middle and Lower Miocene and to some extent in the Middle Oligocene formations. The sands are very lenticular and irregular, and can not be correlated from well to well, rarely even in the case of two adjoining wells. Spindletop field has been an extremely prolific producer—the old cap-rock area has produced approximately 50,000,000 bbl. of oil and the new flank area through 1936 has produced approximately 75,000,000 bbl. of oil. Detail cross sections of the dome suggest the possibility of overhang. If this is true, the dry flanks of the dome may yet offer the possibility of future production.

GRAVITY IN SOUTHEASTERN VIRGINIA.—C. H. Sewick, in BULL. AMER. ASSOC. PETROLEUM GEOLOGISTS, vol. 21 (1937), No. 3, pp. 333–339.

During the summer of 1936, the United States Coast and Geodetic Survey made gravity determinations at 16 stations in Virginia along practically a straight line from the vicinity of Petersburg to the coast southeast of Norfolk. The work was requested by Professors Miller and Ewing of Lehigh University and follows closely a line of seismic determinations made by the latter. The results were reduced by the isostatic method and a profile of isostatic anomalies was thus obtained. The observed values of gravity and other essential data for the stations are given in a table and the results are discussed briefly. The gradual downward slope of the gravity profile toward the east corresponds approximately with the slope of the basement rocks but is somewhat steeper than would be expected from this cause alone unless a very low density is assumed for the overlying material.

CHANGING CONCEPTION OF STRUCTURAL FEATURES IN THE GULF COAST REGION.—Robert P. Clark, in OIL & GAS JOUR., vol. 35 (1937), No. 48, pp. 87–88.

Ever since discovery of the Spindletop field it has been assumed that the dominant structural phenomenon in the Gulf Coast area was the "salt dome," and that discovery of new oilfields depended mainly on the location of new domes. Numerous instances have occurred to prove both the existence of salt domes and the association of oil therewith, but there are many other instances which go to show that oil occurrences in this region are not exclusively confined to dome structures. The Goose Creek and Orange fields failed to show salt at what was then considered great depth, and other "non-salt domes" appeared to cast doubt on the currently accepted theory. A perplexing fact was that production is found in locations remote from the gravitational minima indicative of buried domes. Hence the opinion gained ground that a structural basis, such as a syncline of heavy rocks, would give the same gravitational picture as a salt dome, which is an anticline of light rocks. Two parallel faults with a down-throw in the center will give a structure that is verified by the structural maps of the English Bayou-Gillis or Orange fields.

The point is that the salt dome, either deep or shallow, is not the dominant feature of Gulf Coast oil geology, and oil prospectors deceive themselves if they cling to this single idea. "Oil is where you find it" still remains true; tectonic features such as arching and faulting have no necessary connection with salt domes and provide traps for oil accumulation, and any type of such trap is likely to occur in this field.

DRILLING

MAGNETIC METHODS OF ORIENTING CORES.—G. L. Kothny, in PETR. ENGR., vol. 8 (1937), No. 7, pp. 116–118.

In taking cores in the drilling of oil wells it is desirable to "orient" the core, or to determine its original position in the earth with reference to the points of the compass. Attempts to do this are made by orienting the core barrel out of the hole, by attaching gyroscopic or magnetic compasses to the core barrel, and by other means. When the core has been thus oriented the dip and strike of the strata intersecting the core may readily be determined.

Usual methods of orienting cores are inconvenient, being time consuming and expensive, so the author falls back upon the fact that most sedimentary rocks have a slight permanent magnetic polarity in the direction of the earth's magnetic field. This does not apply to pure limestones, anhydrite or salt, but to sandstones and shales of normal iron content in which small particles of magnetic minerals derived from older rocks have been more or less oriented in the earth's field while settling through water, and have been further magnetized in this field through the millions of years since deposition.

For this purpose the core samples are tested in a special laboratory by means of a highly sensitive magnetometer. The examination should be made on three to five preferably fresh cores showing some indications of a bedding plane, and as taken from the well should be marked "top" or "bottom," otherwise the direction of bedding might be reversed 180 deg. More than 60 percent of the cores examined from all parts of the United States allow of satisfactory determinations.

Value of such knowledge of direction of dip lies not only in the disclosure of structure in wildcat wells, but also in the determination of when wells in proven areas have passed through faults or crossed the axes of symmetrical anticlines into areas where they should be deflected.

LABORATORY ORIENTATION OF WELL CORES BY THEIR MAGNETIC POLARITY.—E. D. Lynton, before Amer. Assoc. Petroleum Geologists, Los Angeles, March, 1937.

A practical laboratory method of orienting well cores by their magnetic polarity was first developed by the Standard Oil Company of California's Research Department early in 1928. The procedure is designed to determine the original orientation in the ground of cores obtained in the ordinary rotary system of oil well drilling. This is accomplished by identifying the north and south sides of a core, after it has been brought to the surface, through residual magnetic polarity in the heavy minerals of the rock. The writer describes the theory and the various steps in developing this idea from the original experimental machine to the commercial one, which is self-recording by photographing the deflections of a light beam.

In conjunction with this magnetic core orienter there has been developed a deviation corrector. Directions of dip obtained from samples cored from crooked holes were worked out as apparent dips and strikes. An instrument, known as a deviation corrector, has been designed to correct rapidly the apparent dip to the true dip, whenever the direction and degree of dip of the hole at the depth from which the core came are known. The instrument and mathematical computations are fully described in this paper.

WELDED JOINT CASING RUN IN A DEEP WELL.—L. G. E. Bignell, in OIL & GAS JOUR., vol. 35 (1937), No. 50, p. 30.

A 5,968-ft. string of 8⅝-in. 36-lb. casing was run into an Oklahoma well, the first flow string of welded casing to be installed in the Mid-Continent. Casing used was of the butt-welded type with U-shaped grooves cut at the factory. The pipe was made in 40-ft. lengths. A special clamp was used for holding two pipes together while the weld was being made, which required about 7½ minutes, including hoisting and lowering. Four welders with two helpers were constantly at work, using the electric method; this method facilitates cooling so that pipe can be handled immediately, and the job was completed in 27 hours. After casing was in position 1,000 sacks of cement were pumped in behind the pipe.

Success of this undertaking is ascribed to the fact that welders were well trained by practicing on short sections of casing in the shop, each being considered proficient if all coupons cut from his work gave 100 percent results when tested in pulling machines.

POLYMERIZATION

ORGANIC CHEMICALS FROM PETROLEUM AND NATURAL GAS.—M. B. Cooke, C. R. Wagner and H. R. Swanson, before Second World Petroleum Congress, Paris, June, 1937.

There are now being made a number of organic chemicals from petroleum and natural gas that are of sufficient interest to attract the attention of both scientists and capitalists. Many such products are also being made from coal tar distillates, but the volume available from this source is not commensurate with the potential demand, particularly those aromatic hydrocarbons that are required in large amounts in times of national emergency. Published figures indicate that less than one percent of coal is converted into aromatics, whereas even by present methods applied to petroleum (by pyrolysis and polymerization) the production of aromatics may be as much as seven to ten percent; and by the process which is the subject of this paper the amount of aromatics obtainable from gas oil may and does amount to 30 percent. This opens the way to a large-scale industry, either in the manufacture of aromatics as the ultimate products, or in the diversion of the olefins used in aromatic syntheses to the production of useful organic chemicals.

The suggestion that paraffin hydrocarbons might be transformed into aromatics dates from 1916, but the idea did not materialize on account of failure to separate the gaseous and liquid products of pyrolysis, and to treat them separately. Experience has proved that aromatic hydrocarbons are polymerization products of acetylene and ethylene hydrocarbons as well as the result of the splitting of polycyclic compounds, but these processes require the conjunction of optimum pressure and temperature in order to obtain the optimum degree of conversion. The fault of the earlier proposals was that the exothermic nature of the polymerization reaction was not clearly recognized and that the attempt was made to carry out an endothermic reaction—pyrolysis—in the presence of a definitely exothermic process of polymerization.

Due account of this latter fact is taken in the Pure Oil Co. (Alco) process. Another fundamental matter in the art of pyrolysis and polymerization as here applied is the direct quenching of the reaction products so as accurately to control the time of reaction which is a matter of seconds rather than of minutes, and one which no indirect cooling device will adequately handle.

The Pure Oil Company and Alco Products, Inc. have developed a polymerization process for producing high percentages of aromatics of relatively high purity as compared with the coal tar distillates containing aromatics. The raw material for aromatic production is either by-product refinery gases or crude oil.

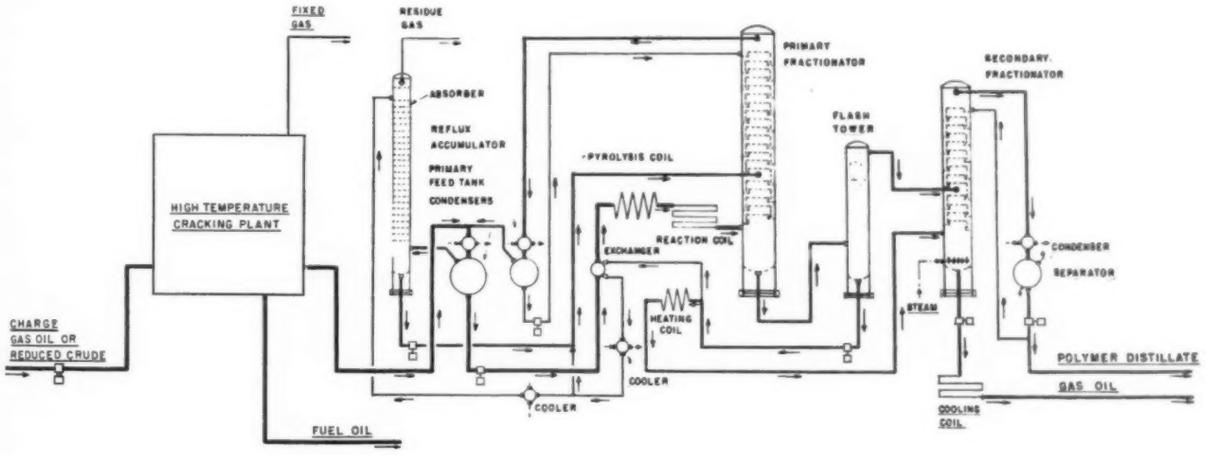
The charging stock for the polymerization unit which is most readily collected is fractionator residue gas, commonly called "stabilizer overhead." The next most convenient source in a modern refinery is absorber residue, commonly called "absorber tail gas." Typical gases from a vapor phase cracking unit are represented by the following analyses:

Composition of Polymerization Unit Feed Stock

	Mol % Fractionator Residue	Mol % Absorber Residue
CO_2	0.4	0.0
CH_4–H_2	4.9	38.0
C_2H_4	7.9	25.5
C_2H_6	14.5	13.8
C_3H_6	23.0	16.8
C_3H_8	22.2	3.1
C_4H_8	17.7	2.0
C_4H_{10}	9.7	0.8
C_5 plus	0.2	....
Unsaturates	48.1	44.3
Spec. Grav. (Air=1)	1.518	0.993

The development work on this process was carried on with the normally gaseous hydrocarbons with C_3 as the heaviest constituent. On account of the interest in the subject of aromatics from petroleum as well as from such gases, the process utilizing gas oil as charging stock for the pyrolysis step is described. The plant was designed to process 300 metric tons of gas oil per stream day,

AROMATICS FROM PETROLEUM



Based on processing the above charging stock the estimated yields of products are as follows:

	Weight percent of original charge
Gas	40
Aromatic Distillate	30
Fuel Oil	30
Total	100

A schematic flow sheet of this gas oil or reduced crude unit is shown in the accompanying diagram.

Distillation Data

(A.S.T.M.)
Aromatic Poly Distillate
After Treating

Gravity, A.P.I.	31.2
Initial Boiling Point	166 deg. F.
5%	190
10%	195
20%	202
30%	209
40%	217
50%	226
60%	239
70%	257
80%	288
90%	336
95%	366
End Point	387
Recovery	99%
Residue	1%
Loss	0
Color, Saybolt	+30

and recovers about 30 percent by weight of aromatic distillate. This distillate contains approximately 24 weight percent boiling within the temperature range 215 deg.–240 deg. F., representing 7.2 weight percent of the original charge or approximately 6,500 tons per year based on 300 operating days.

APPROXIMATE OPERATING CONDITIONS

Capacity and Charge:

The plant processes 300 metric tons per stream day of uncracked gas oil, having the following characteristics:

Source	Mixed Base Crude
Gravity, A.P.I.	34
Gravity, Specific	.885
Sulphur, maximum	.1
Paraffinicity	11.7–11.8

Approximate boiling points:

Initial Boiling Point	350–400 deg. F.
10%	440–460 deg. F.
50%	510–530 deg. F.
90%	650–675 deg. F.
End Point, maximum	700 deg. F.

The aromatic distillate, by Podbielniak analysis, contains not less than 24 weight percent boiling between 215 and 240 deg. F. See accompanying table for distillation data.

From this development work there has been a great amount of data collected which has led to a new basic process for producing olefins as intermediates which will be used by the organic chemical industry. The pyrolysis studies carried on in conjunction with polymerization have resulted in the development of commercial processes for pyrolyzing saturated gases as well as gas oil or reduced crude oil to yield gases which are high in olefin content.

Alco Products, Inc. has been able to separate about 90 percent of the ethylene from a cracked gas containing from 20–30 percent ethylene, as a fraction containing as much as 98 percent ethylene and 2 percent ethane as an impurity.

This ethylene of 90–98 percent purity will serve without further treatment as ideal raw material to produce by direct synthesis anhydrous ethyl alcohol at a very low cost; also ethyl chloride, ethylene chlorohydrine, ethylene dichloride, dibrimode, and numerous other ethylene derivatives, which among other purposes will serve for the manufacture of safety explosives such as glycol dinitrate, and also for the manufacture of glycol anti-freeze liquids.

Copies of this complete paper will be furnished on request, Alco Products, Inc., 30 Church St., New York: Artillery House, Artillery Row, London, S. W. 1, England.

TRANSPORTATION

Asbestos-Cement Pipe for Conveying Salt Water.—Leo H. Towers, in PETR. ENG., vol. 8 (1937), No. 7, pp. 51–52.

In western Kansas asbestos-cement pipe is used to transport salt water from the oil wells to an unobjectionable point of disposal, as required by law. So far more than 125 miles of this piping have been laid for salt water disposal in Kansas and Oklahoma, the longest single line being seven miles. A 13-ft. joint of 6-in. pipe of average pressure weighs approximately 130 lb. and can easily be laid in the ditch by two men.

Asbestos-cement pipe is limited in its applications in the oil industry to pressures under 200 lbs. In addition to its use in salt water disposal it finds employment in lead lines for "sour" or corrosive crudes, for fresh water supply lines, low pressure acid lines about refineries, smoke stacks on pipeline pumping stations, etc. It is made of 85 percent Portland cement and 15 percent asbestos fiber, which amounts to 50:50 by volume; the asbestos functions as a reinforcing material.

Joints are made with an asbestos-cement coupling and two rubber rings of 75 percent pure rubber, giving a water-tight joint that appears to last indefinitely, but what effect oil will have on these rings is not yet definitely known.

Metering for Road Tank Cars—C. Le M. Gosselin in PETROLEUM TIMES, vol. 37, (1937) No. 952, pp. 476–7.

An obstacle to the growing practice of fitting meters on tank trucks has in the past been brought about by suctioning of air and its by-passing through the meter while oil is being delivered. A combined meter and air-box has been developed to overcome this. The conduit between the truck's tank and receiving tank is provided with a pivotally mounted valve on the inlet side of the meter, controllable through a float by the level of the liquid in an auxiliary chamber in series with the conduit. The air-box prevents air from entering the meter at commencement, or from being drawn through the meter on conclusion, of delivery. If the air-box were not fitted the air would be registered by the meter.

Progress in Rapid and Efficient Pipeline Construction.—T. R. Jones, in PIPE LINE NEWS, vol. 9 (1937), No. 5, pp. 5–8.

The welding of pipelines has made large progress within the past 15 years, both in materials and practices, but there still exist certain elements of unbalance in the organization of operations that are keeping achievement below the ultimate. The author favors the all-bellhole welding method and has used it in the laying of a good many relatively short lines in Texas, and recently applied it to the laying of 50 miles of 10-inch in Kansas. This represented fairly large scale procedure, and a careful analysis was made from the standpoint of efficient organization and low cost of operations. This method of pipelining, which is called "stove piping" in the field, involves considerable departure from the older practices. The bending gang is moved up to the front end and consolidated with the line-up and tacking gang; the firing line and bellhole gang have been consolidated into a single welding organization. Pipe is bent in single or multiple sections and aligned on skids over the open ditch. When properly aligned, the joint is tacked and the front end gang moves on to the next joint.

With technical improvements in the welding process which have increased bellhole welding speed, it would appear that improvements are necessary in the purely mechanical operations in order to keep pace with present day welding ability. There are two factors which tend to reduce progress with the stove pipe method. These are the speed with which the pipe can be bent, and the footage of ditch which can be opened per day. Anything that can be done to speed up these operations will enable the contractor to weld increased footage at lower costs. Ditching machines are kept running 24 hours a day at the present time and frequently the welding is held up because of lack of sufficient ditch.

Higher strength material has led to the substitution of lighter wall pipe for equivalent operating conditions. Part of this trend toward lighter wall is due to these improved physical characteristics and part to a more scientific attitude toward soil corrosion.

Some of the oil companies have even gone so far in this matter of combating corrosion to make soil surveys along the right-of-way determining scientifically to what extent wrapping or coating shall be used.

In all likelihood some consideration will be given in the near future to the use of Class C material having still higher physical properties as technique for combating corrosion effects is developed. If and when this material, having actual ultimate strength in the neighborhood of 85,000 to 90,000 lb. per sq. in., becomes a reality it may present new problems of welding if joints as strong as the metal itself are obtained.

In the past two years experiments have been made with Naylor spiral-welded pipe which may have a bearing on the moot question of whether large diameter pipes should be welded or coupled in order to allow for expansion and contraction. This pipe has an upstanding ridge where the spiral weld is made and there is a certain amount of flexibility to withstand expansion or contraction. Several short lines up to several miles long have been laid in 24 in. pipe, which has been solidly welded together and laid into the ditch without any attempt whatsoever of putting compression on the line. This sort of pipe develops an excellent ground friction due to the upstanding seams and practically no movement of the pipe can take place after the ditch has been backfilled. It is said that these tests have been carried practically to the point where all concerned are convinced of the feasibility of laying lines of any length by this method.

Progress Report on Pipe Coating.—Kirk H. Logan and Scott B. Ewing in BUR. STANDARDS JOURNAL OF RESEARCH, March, 1937.

Continuing the study of corrosion-resisting coatings for metals initiated by the Bureau of Standards in 1922 the present report covers results of all coatings tested from 1932; these coatings were mostly applied to steel pipe. Conclusions are stated as follows:

1. With exception of lead-treated specimens, all coatings treated in this report appear to have reduced the rate of corrosion of steel during the period of test.

2. No coatings have a perfect record for all specimens removed, although in some cases of short-time exposures rusting of protected pipe was probably caused by moisture entering through ends of the specimens, and not through the coating.

3. Specimens calorized by the powder method showed somewhat higher rates of loss of weight and somewhat lower rates of maximum penetration than those calorized by the dip process.

4. Lead is sufficiently corrodible in most soils to result in perforation of lead coatings of the thickness used in these tests within 10 years. After the lead has been punctured, accelerated corrosion may occur because of the difference of potential between lead and steel.

5. Over a 10-year period, the rates of loss of weight of galvanized steel were from one-half to one-fifth the rates for bare steel.

6. Galvanized steel corrodes most rapidly in poorly drained acid soils and in slaty soils.

7. For long periods of exposure, thick zinc coatings are superior to thin ones. A coating of 2.8 oz. per sq. ft. of exposed surface prevented the formation of measurable pits in all but one soil for a period of ten years.

8. Type of ferrous material to which zinc is applied does not have an appreciable effect on rate of corrosion of galvanized materials during the first ten years of exposure.

9. Rate of corrosion of galvanized steel is lower than that of either zinc or steel alone.

10. Foundry and mill scale do not protect ferrous materials against underground corrosion.

11. Coverings over the lead sheath in parkway cable prevent serious corrosion of the sheath for a period of at least 12 years.

12. Of a group of non-metallic and non-bituminous coatings, vitreous-enamel and hard rubber coatings afford the best protection over a 2-year period of exposure. Thin coatings in this group permitted moisture to reach the pipe and rusting followed.

13. It is not possible to determine from data presented whether or not any coatings would be advisable under any of the soil conditions studied because this is an economic problem depending largely on cost of the coating and other factors.

PETROLEUM REFINING

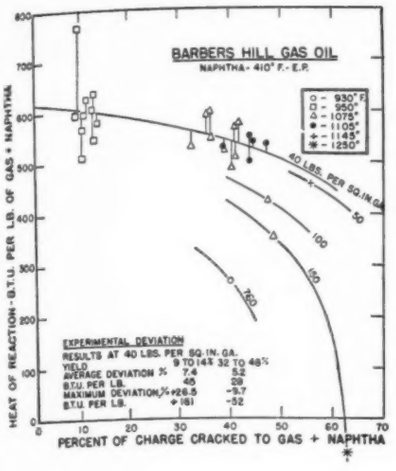
Desulphurizing Iraq Crude Oils by Means of Powdered Copper.—Ch. Baron, in ANN. OFFICE NATIONAL COMBUSTIBLES LIQUIDES, vol. 12 (1937), No. 1, pp. 25–28.

Experiments show that it is a simple matter to desulphurize Iraq crudes by using very finely divided metallic copper. Ninety percent of the sulphur is recoverable as SO_2 by roasting the copper sulphides; the regenerated copper is returned to the process. France imports 3,000,000 tons of Iraq crude a year; this crude contains 2 percent of sulphur, which depreciates the value of the crude by Fr. 20 a ton, or a total depreciation of Fr. 60,000,000 annually. Calculation shows that the copper desulphurization method offers a handsome margin of profit.

Heat of Reaction of Cracking Petroleum.—H. M. Weir and G. L. Eaton, in IND. ENG. CHEM., vol. 29 (1937), No. 3, pp. 346–353.

The commercial cracking operation, as applied for the production of gasoline, involves a large and undetermined number of simultaneous and consecutive reactions in which both decomposition and polymerization occur. The chemistry of these operations is so complex that it is doubtful if they will ever be completely described in terms of the separate reactions. However, interest centers in the net result. In this paper the term "heat of the cracking reaction" refers to the net heat effect of the many simultaneous and consecutive reactions which occur.

An experimental study, made in 1931, of the heat of reaction of cracking two different types of virgin gas oil and one refractory recycle stock is reported. A continuous calorimetric method was employed, in which the heat required for the cracking reaction was added in the interior of an isothermal reaction chamber. Somewhat extended ranges of temperature, pressure, and amount of cracking were covered, and several new concepts are reached. The results indicate that temperature is not of prime importance in its effect on the heat of reaction when weight of gas and naphtha produced is taken as the measure of the reaction. *It appears that pressure and depth of cracking are of far greater significance.* When attention is focused on the molecular bonds broken, and the heat of reaction is expressed as b.t.u. per pound mole of new material produced, the pressure factor drops out, leaving only charge


BARBERS HILL GAS OIL
NAPHTHA - 410° F. - E.P.
O - 930° F.
□ - 950°
△ - 1075°
● - 1105°
+ - 1145°
✱ - 1250°
40 LBS. PER SQ. IN. GA.
50
100
150
760
HEAT OF REACTION - B.T.U. PER LB. OF GAS + NAPHTHA
PERCENT OF CHARGE CRACKED TO GAS + NAPHTHA
EXPERIMENTAL DEVIATION
RESULTS AT 40 LBS. PER SQ. IN. GA.
YIELD 9 TO 14% 32 TO 46%
AVERAGE DEVIATION % 7.4 5.2
B.T.U. PER LB. 65 59
MAXIMUM DEVIATION % +26.5 -9.7
B.T.U. PER LB. +161 -52

stock and depth of cracking as important variables.

The application of the experimental results to plant data has led to considerable confidence in their general utility for design purposes, heat balances on operating units, etc.

A general picture of the results may be seen in the accompanying diagram. This diagram relates the heat input per pound of gas plus gasoline (410 deg. F. end-point) formed in the reaction chamber to the weight percent of Barbers Hill gas oil which emerged as gas and gasoline. Still more complete data are reported with virgin East Texas gas oil as charging stock. Here a substantial change in the heat of reaction with pressure was encountered. All attempts to make a correlation between heat of cracking and temperature were fruitless, as were attempts to correlate reaction time and heat of cracking.

AIR FILTERS IN OIL REFINERIES.—E. Kundig, in REFINER, vol. 16 (1937), No. 3, pp. 141–143.

The recent prevalence of dust storms has made oil refinery engineers dust-conscious, and much interest is being shown in air filtration. It is being recognized that, while the prevalence of gritty particles in the atmosphere during dust storms is fairly obvious, the dust present in ordinary "clean" air is none the less deserving of attention because it is not obvious. Normal atmospheric air contains about four grains of dust per 1,000 cu. ft. of air; these dust particles are largely silica and carbon. On this basis it may be calculated that a 150 h.p. internal combustion engine taking about 1,000 cu. ft. of air per minute will in 30 operating 8-hour days draw in about 8½ lbs. of fine abrasive dust which hastens the wear of valves, cylinders and liners and destroys the body of the lubricating oil. The author vouches for the statement that by keeping this dust out of the engine, up to 75 percent savings are assured in cost of upkeep and in preservation of the oil.

The main requirements of an air filter are that it shall be capable of arresting dust particles no larger than one to three microns (1 micron = 0.0004 inch) and at the same time permit the passage of air in sufficient volume.

It is not only of importance to filter air going to internal combustion engines, but also the air used to cool electric motors in order to prevent contamination of commutators and windings by either dust or oil particles.

CURRENT RESEARCH WORK ON SOLVENT REFINING OF MINERAL OIL.—L. C. Strang, in OIL & GAS JOUR., vol. 35 (1937), No. 45, pp. 98–103.

A good lubricating oil should have a low viscosity-gravity constant, a high viscosity index and a low pourpoint, hence it is necessary to remove the naphthenic constituents and wax from the oil stock by a suitable refining process, as by the use of selective solvents. The question of effecting transfer of undesirable constituents to the solvent thus becomes a subject for desirable fundamental research, which the author has conducted at the Birmingham University (England).

This research has shown that mass transfer between two liquids can be treated in the same way as mass transfer between a gas and a liquid and that the overall resistance to mass transfer in a liquid-liquid system can be considered as made up of two individual film resistances, each dependent on the physical and dynamical properties prevailing in the two liquids.

On the basis of this principle a simple graphical method has been established for representing the complex equilibrium relationships in a solvent-oil system and a method for calculating results to be expected from a solvent dewaxing process. The work has been carried out to establish principles and not to set forth the advantages or disadvantages of particular solvents, with expectation that the oil technologist will be able to apply the results of investigation to systems in which he is interested.

WHAT REFINERS HAVE NOT DONE.—W. L. Nelson, in OIL & GAS JOUR., vol. 35 (1937), No. 45, pp. 82–83.

Notwithstanding impressive technical accomplishments of the oil industry in recent times, there are still many moot questions and technical problems that the oil technologists have not yet overcome, partly for lack of understanding and in part from inertia and reluctance to depart from habit. For instance, much argument has been expended on the requirement that gasoline should be water white, which most technical men feel is unnecessary and puts too much cost on both the industry and the public.

Then there is the question of permissible sulphur content of gasoline. All are agreed that some kinds of sulphur are harmful and others less so, but the refining industry has not yet stirred itself to invent a rational sulphur test.

Trend of refinery practice is now definitely established toward highly technical processes; up to recently this trend has been manifest chiefly in the physical aspects of heating, exact fractionating, continuous processes, automatic controls, etc., whereas chemical technology is now becoming the center of attention. Heretofore, crude oil has been separated into commercial products mainly by distillation, the products being accepted as they are, with little attempt, however, to reconstruct them into more desirable materials. Only one such chemical process—cracking—has been extensively used, but polymerization, solvent extraction and hydrogenation lie just ahead, waiting for the refiners to develop them.

Then there is the so-called "catalytic age", which the oil industry is just entering, and which some have already hailed as a time when crude oil will be merely a source of carbon and hydrogen to be taken apart and rebuilt into all sorts of desirable and profitable products. This may at present seem merely a dream but let oil reserves become depleted, and a purely synthetic petroleum industry will enter the realm of possibility (and may find some refiners unprepared).

The real stumbling block to rapid advancement in both the physical and chemical development of the industry is the lack of adequate physical and chemical data; while a few individuals and organizations are devoting themselves to fundamental studies it is surprising that the petroleum industry, which has a reputation for energy, has delayed so long in securing such data. The fact is that we do not know what compounds are present in our crude material, and we have little or no guidance as to the natures of the mixtures we are handling. No great progress in either the physical or chemical branches of the industry is possible until this confusion is cleared up by fundamental research; which will be worth cooperative action on a large scale by the entire industry.

Among other wishful aspirations of the oil industry is some means of reducing the annual $100,000,000 bill due to corrosion. Another is for some means that will absolutely free crude oil going to the refinery from expensive traces of water and sediment. Then there is the unending debate over relative merits of natural and cracked asphalt. It is still a fact that no one yet knows exactly how many plates in a fractionating tower are necessary to get a particular boiling-range product. And some means of saving the 2,000,000,000,000 cu. ft. of gas that are annually and shamefully wasted is a crying necessity.

It is true that further development of many processes is held in check by present economic conditions and the cost of power; both hydrogenation and adoption of high-speed Diesels are examples of possibilities that have been suppressed by economic conditions which sooner or later may be subject to change.

ANTIOXIDANTS AS STABILIZERS FOR CRACKED MOTOR FUELS.—C. G. Dryer, J. C. Morrell and Gustav Egloff, in OIL AND GAS JOUR., vol. 35 (1937), No. 45, pp. 113–117.

Antioxidants have been successfully used in cracked gasolines in the United States for a number of years, and are being commercially used to a considerable extent in Europe. In small concentrations they prevent gum formation, deterioration of color and loss in anti-knock value. Application of inhibitors has made it possible to reduce, and in some cases eliminate, chemical treatment other than sweetening.

Primary requirement of an antioxidant is that it gives satisfactory inhibiting value at minimum cost, but it must have other properties if it is to be satisfactory in commercial use. The desirable form of an antioxidant is a liquid or a concentrated solution readily soluble in gasoline or, preferably, miscible with gasoline in all proportions. A commercial antioxidant should have low solubility in water to avoid removal of inhibitor from gasoline when unavoidably contacted with water either in refinery or distribution systems. An antioxidant not greatly affected by presence of alkaline water is desirable since occasionally gasolines contain traces of alkali due to insufficient water washing or settling after doctor treatment. An antioxidant should not decrease initial color of gasoline, should protect against darkening in storage, and occasion minimum discoloration upon exposure to light. An antioxidant should be sufficiently volatile to avoid formation of deposits in carburetor jets and other parts of the fuel system.

Among the antioxidants which have gained commercial acceptance are U.O.P. inhibitors 1 and 4. Inhibitor 1 is a specially prepared wood tar distillate. Inhibitor 4 is another product specially developed for use in cracked gasoline. Both inhibitors are liquids, readily soluble in gasoline, volatile with it and possessing definite color inhibiting properties in dark storage.

Tests with these inhibitors in comparison with catechol showed that inhibitor 4 is approximately six to ten times as effective as inhibitor 1; the ratio between 1 and catechol is about 1:3.5. Inhibitor 4 is far less removable by water and alkali than catechol, and considerably less than inhibitor 1. The most general method of using an inhibitor is to sweeten the stabilized gasoline, settle it thoroughly and add the inhibitor as the gasoline is run to storage.

It is of particular importance in the use of inhibitors to know what properties the gasoline must have to assure satisfactory stability in storage. Many tests have been proposed for prediction of storage stability. In the opinion of the authors, who have had much experience in this field, best criterion of storage stability is a combination of induction period and copper dish gum; neither test alone is conclusive, but when a gasoline has a long induction period and a low gum test a storage life of many months may be expected.

PETROLEUM CHEMISTRY

Desulphurization of Motor Fuels by Adsorption.—R. Dubrisay, in ANN. OFF. NAT. CARB. LIQUIDES, vol. 12 (1937), No. 1, pp. 29–35.

Among the effective adsorbing substances is alumina; its capacity for adsorbing sulphur compounds is greatly enhanced by thorough drying, particularly when used for deodorizing white spirit that is contaminated by hydrogen sulphide or mercaptans. The hydrogen sulphide is completely adsorbed, but a part of it is oxidized with liberation of free sulphur, some of which is dissolved in the oil. Various substances were employed in the endeavor to remove this sulphur, but complete desulphurization of the white spirit could be effected only by the use of powdered copper. On the other hand, removal of hydrogen sulphide by means of certain kaolinites was more successful.

The sulphur-removing capabilities of alumina and copper may be combined by saturating alumina with copper nitrate and calcining the mixture. When added to hot oil this preparation has a remarkable power of adsorbing sulphur.

Flammability of Propane-Air Mixtures.—H. W. von der Hoeven, in IND. ENG. CHEM., vol. 29 (1937), No. 4, pp. 445–446.

Although the explosive properties of mixtures of combustible gases and air have been repeatedly examined, there is a dearth of information relating to flammability at pressures below atmospheric. Such data are here supplied for propane-air mixtures. It was found that the explosion point depends on the strength of the electric spark; no explosion could be obtained below a pressure of 210 mm. of mercury even with a strong spark. In any case, the flammability of propane-air mixtures is less than for methane-air.

Cracking Research on Roumanian Kerosene.—C. Otin and M. Dima, in PETROLEUM, vol. 33 (1937), No. 12, pp. 1–7.

Recent work and patents have revived some interest in the use of aluminum chloride as a catalytic cracking agent. The idea now is to allow hydrochloric acid to act upon "activated" metallic aluminium in the oil to be cracked; under such circumstances aluminium chloride is produced in the finest state of division and has a high reactivity. The reactivity of this activated aluminium chloride is ascribed to the tendency of the aluminium atom, which in aluminium chloride has only six electrons in its outer shell, to assume the more stable eight-shell. This disturbs and loosens the C-C- and H-C bonds of the hydrocarbons, leading to the formation of unsaturated complex compounds of aluminium chloride and hydrocarbons; these readily decompose and the resulting unsaturated hydrocarbons are hydrogenated by the hydrogen set free by the aluminium chloride.

The authors applied this idea to a Roumanian kerosene boiling within the range 158 deg. to 300 deg. C. Spirally rolled strips of aluminium are activated with one percent of mercury and placed in the dry kerosene. Heat is applied while gaseous hydrochloric acid is led into the reaction vessel. The most suitable reaction temperature is 200 deg.–230 deg. C. Under these circumstances the kerosene is converted into gasoline with a boiling range of 28 deg. to 200 deg. C. The yield varied between 79 and 92 percent.

Aniline Points of Hydrocarbons.—E. B. Evans, in JOUR. INST. PETROLEUM TECHNOLOGISTS, vol. 23 (1937), No. 161, pp. 220–225.

Critical solution temperatures (C.S.T.) of hydrocarbons in various solvents afford valuable aid in the analysis of hydrocarbon mixtures; practically it amounts to a determination of the temperature of miscibility of equal volumes of aniline and the hydrocarbon. It is very surprising that this eminently practical suggestion has not been universally adopted, since the advantages are obvious, and there is no particular theoretical consideration attaching to the C.S.T. in this connection. The reason has been, perhaps, that at the time the suggestion was made a fair amount of data had been accumulated in terms of the older value. Much of the earlier data recorded for the C.S.T.'s of hydrocarbons is now of little value, as it is for various reasons inaccurate, and it is unfortunate that carefully determined figures on pure compounds still continue to be given in this form.

The solution temperature method is very widely used in analysis of gasolines and kerosenes. Considerable confusion exists, however, between critical solution temperatures and aniline points, and the terms and data are used indiscriminately in many cases in the literature, although results may in some instances differ very considerably.

The main sources of error which may arise in the determination of aniline point data may be divided into two classes. In many cases insufficient care has been taken to obtain pure compounds on which to carry out measurements, and the resulting figure can easily be several degrees out on this account, since solution temperature is a very sensitive property. The other main source of error is the use of impure aniline. The effect of water content in raising the aniline point has been emphasized by Ormandy and Craven, but the importance of other impurities, such as nitrobenzene, which act in the opposite direction, does not seem to have been adequately recognized.

Using compounds of known high purity the author has redetermined the aniline points of a number of hydrocarbons; the results are given in a table. The analysis of gasoline by the aniline point method has been put on a satisfactory basis by Garner (J. Inst. Petr. Tech., vol. 14, p. 695), and the factors there given are in good agreement with the results shown in the present paper.

PETROLEUM PHYSICS

Solidification Phenomena in Mineral Oils.—A. Bondi, in PETROLEUM, vol. 33 (1937), No. 14, pp. 1–5.

Aberrations of viscosity relations of mineral oils in regard to solidifying or pour points have been ascribed for the most part to the paraffin content. Mere separation of the paraffin does not tell the whole story; it is shown that solidifying of mineral oils is accompanied by a noticeable evolution of heat, especially when paraffin crystals begin to separate. Such practical importance as this phenomenon may have lies in the analytical field. The cooling process itself is perceptibly delayed by the heat of solidification, and all changes in the properties of a lubricating oil due to paraffin separation proceed very slowly. Consequently it will be necessary to allow test samples to stand as long as possible at a definite temperature before examination is begun in order that comparable results may be obtained.

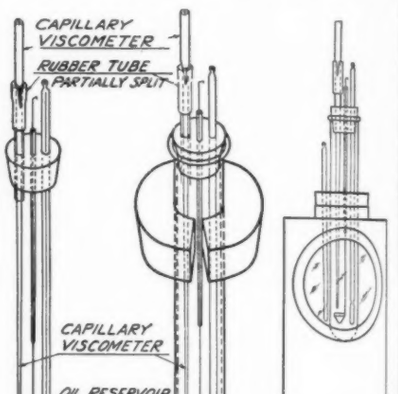
Molecular Weights of Viscous Petroleum Fractions.—J. R. Keith and L. C. Roess, in IND. ENG. CHEM., vol. 29 (1937), No. 4, pp. 460–464.

The molecular weights of petroleum fractions boiling within the light lubricating-oil range having been correlated with their viscosities by Fenske *et al.* The authors of this paper perform a similar service for oils of wider boiling range and widely different viscosity-temperature characteristics. They worked on Texas Coastal and Mid-Continent crude distillates. The two curves obtained by them relating molecular weight and viscosity show very satisfactory correlation, which has been reduced to a mathematical form that permits prediction of the molecular weight from viscosities at 100 deg. and 210 deg. F.

Molecular weight data from the literature were compared with this correlation, and it is concluded that the molecular weight of any petroleum fraction can be predicted with a probable error of ±3 percent. The actual error depends largely on the accuracy with which viscosities can be determined, but it appears that, if reasonable care is exercised, the predicted molecular weights will be well within the usual accuracy of engineering calculations.

Micromethod for Determining Viscosity of Lubricating Oils.—Harry Levin, in IND. ENG. CHEM., analyt. edit., vol. 9 (1937), No. 3, pp. 147–149.

Without being habitually concerned with micro quantities of sample as are those engaged in biological sciences, even in industrial oil laboratories one has frequent need for information as to viscosity of very small samples. As a result a method has been developed for determining absolute viscosity on about 15 mg. of material which has found application in numerous instances where small amounts of material were available.



This illustration was incorrectly used on page 64, May World Petroleum

The method is based on the rate of rise of the oil into a fine vertical capillary, the actuating force being surface tension, and is preferably used with only a few milligrams of material.

Viscosity measurements based on the rate of rise into a capillary have long been made in the petroleum industry on kerosenes by means of the Saybolt thermoviscometer; but here the actuating force is the head of oil, not its surface tension, and the sample needed is approximately a pint.

A view of the apparatus used is shown in the accompanying sketch. It contains a capillary viscometer consisting of a glass tube having a length of about 8 cm. of substantially uniform bore at the lower end; this tube has an etched mark 25 mm. above the small end, another 13 mm. above that, and a third at 13 mm. above the second. In operation a small quantity of the oil is placed in a small conical cup attached to a wire so that the cap can be raised or lowered. The apparatus is placed in a thermostat until the desired temperature has been reached, the tip of the capillary tube is lowered to the surface of the oil, a stop watch is started and the time noted for the meniscus to pass the three marks. The result is then interpreted in absolute viscosity in centipoises by reference to a curve previously based on samples of known viscosity.

TABLE OF SPECIFIC GRAVITY CORRECTION FACTORS FOR PETROLEUM OILS.—E. S. L. Beale, in JOUR. INST. PETROLEUM TECHNOLOGISTS, vol. 23 (1937), No. 161, pp. 213–219.

The well-known Bureau of Standards Circular No. 154 has been taken as the basis for the calculation of a standard table of specific gravity correction factors, which are shown to give the same results when used in the ordinary way as the elaborate tables in the circular; see accompanying table.

A Standard Table of Specific Gravity Correction Factors for Petroleum Products

Specific Gravity at 60° F.	Correction Factor per ° F.	Specific Gravity at 60° F.	Correction Factor per ° F.
615 to 625	0.00055	746 to 756	0.00044
625 " 635	0.00054	756 " 765	0.00043
635 " 645	0.00053	765 " 775	0.00042
645 " 656	0.00052	775 " 786	0.00041
656 " 667	0.00051	786 " 798	0.00040
667 " 680	0.00050	798 " 814	0.00039
680 " 692	0.00049	814 " 830	0.00038
692 " 707	0.00048	830 " 850	0.00037
707 " 720	0.00047	850 " 890	0.00036
720 " 734	0.00046	890 " 960	0.00035
734 " 746	0.00045	960 and over	0.00034

The method adopted has been to calculate the mean correction over temperature range 60 deg. to 120 deg. F. from the tables for oils of S.G. 0.726 and heavier, and over the range 60 deg. to 90 deg. F. for oils lighter than 0.726. These values were plotted on a large-scale graph, and this was then divided into steps of 0.00001 per deg. F., and the range of S.G. over which each of these is applicable was read from the curve.

Attention is directed to errors introduced by the use of the Abridged Volume Correction Table issued by the A.S.T.M., which is based on the same data as Circular No. 154, and also errors which may be caused by a considerable change in the apparent value of the correction factors of waxy oils at low temperatures.

ASPHALT AND TAR

PHYSICAL PROPERTIES OF ASPHALT.—Seward Mason, R. J. Loomis, S. D. Patterson, H. G. Nevitt and L. C. Krchma, in IND. ENG. CHEM., analyt. edit., vol. 9 (1937), No. 3, pp. 138–139

In this investigation the viscosity-temperature characteristics of several domestic asphalts and one Mexican asphalt were studied over the usual penetration ranges, using the viscosity-temperature susceptibility coefficient (Nevitt and Krchma), as the index.

Standard A. S. T. M. procedures were employed wherever possible. The penetrations were determined at 25 deg. C. exactly following the A. S. T. M. procedure. The viscosities were determined at 98.89 deg. C. (210 deg. F.) and 135 deg. C. (275 deg. F.) using a thermostatically controlled Saybolt viscosimeter with interchangeable Universal, Furol and asphalt orifices.

The uniformity over the consistency range of the various asphalts investigated confirms the conclusion that the viscosity-temperature susceptibility coefficient is a suitable index and, using the Standard Saybolt viscometer, it is an index readily applicable at the present stage of asphalt technology.

THE PLASTICITY RANGE OF CERTAIN ROUMANIAN ASPHALT-BITUMENS.—V. Cerchez, E. Arion and V. Niculescu, in OEL UND KOHLE, vol. 13 (1937), No. 14, 321–324.

Asphalt-bitumens have no real melting point, but there is a more or less indistinctly defined low temperature at which these substances become positively solid, and an equally indefinite higher temperature at which they become positively liquid. Heretofore it has been difficult to define this temperature range for lack of a suitable method of determining the solidification point. This inconvenience has been removed by introduction of the Hoepfner and Metzger penetrometer method, by which point of solidification is defined as the temperature at which a needle, under a load of 450 grams will sink into the bitumen at the rate of one tenth of a millimeter a minute. The fluidity point is determined by the drop point method according to Ubbelohde. In between these two points is a third point called the softening point, which is determined according to the method of Kraemer-Sarnow.

From this investigation it is deduced that the plasticity range of an asphalt-bitumen changes according to the softening point, but it is found that asphalt-bitumens with the same softening points may have different plasticity ranges. This gives another method of differentiating between various road building materials from the commercial and road-engineering standpoints.

INTERNATIONAL BITUMEN MARKET 1935.—Walther Schmidt, in PETROLEUM, vol. 33 (1937), No. 8, pp. 4–9.

World statistics on bitumen are still to a considerable extent based on estimates but several countries have begun to differentiate between bitumen and asphalt in their trade figures, and it may be said that the general picture of this, while still obscure in some parts, is now more complete than ever. According to available data and estimates the position as to production during the past three years is as in the accompanying table.

COUNTRY	1933	1934	1935
		In Metric Tons	
United States	3,015,440	3,460,390	3,924,100
Mexico	150,030	293,240	310,420
Canada	99,890	118,170	*127,000*
Argentina	10,160	10,160	*14,000*
Venezuela	3,490	3,490	*6,530*
Cuba	1,320	3,960	*3,960*
Colombia	3,520	2,920	*1,800*
Peru	0,580	1,250	*1,250*
Other America	2,570	2,240	*2,940*
All Americas	3,287,000	3,896,000	4,392,000
Great Britain	343,380	*416,680*	*419,120*
Germany	339,240	*338,000*	*420,000*
France	221,370	251,500	*269,850*
Russia	146,220	*164,700*	*172,670*
Roumania	59,310	84,220	84,290
Holland	42,950	51,460	*47,920*
Italy	13,340	12,060	*35,620*
Poland	22,180	22,840	*20,630*
Sweden	16,400	18,580	*18,580*
Other Europe	*5,610*	9,960	*17,320*
All Europe	1,210,000	1,370,000	1,506,000
Japan	75,720	86,580	93,950
Netherland India	7,640	7,100	*7,780*
Other Asia	*640*	*1,320*	*1,270*
All Asia	84,000	95,000	103,000
Egypt	48,640	58,560	*88,000*
Other Africa	*360*	*440*	*1,000*
All Africa	49,000	59,000	89,000
The World	4,630,000	5,420,000	6,090,000

Figures in italics are estimates. Figures for Holland and Belgium do not differentiate between production and export.

Production in the United States alone is more than two thirds of the total, but Mexico, with 281,970 tons, is the leading exporter of bitumen; this is nearly a third of the total world export (975,000 t.). The only countries with an excess of production over consumption are in the Americas.

The production of natural asphalt is to that of bitumen as 2.6: 97.4. In addition to Trinidad, Cuba, Germany, France, Albania, Switzerland and Syria, new sources of production are in Iraq and the Philippines.

ROAD ASPHALTS FROM HEAVY ARKANSAS CRUDES.—W. M. Carney, in OIL & GAS JOUR., vol. 35 (1937), No. 45, pp. 111–112.

In the operations here described crude is introduced into the system by passing through heat exchangers and absorbing heat from overhead lube distillate vapors or vacuum tower bottoms, which may be either asphalt or fluxing oil. The charge then goes to the first coil of the furnace where it is heated to temperature required for distillation of gasoline and gas oils, after being flashed into atmospheric pressure fractionating towers. Flash-tower bottoms are then returned by a hot-oil pump to the second coil of the furnace and the temperature is raised sufficiently to support heat of vaporization required, depending on the asphalt product desired; and flashed into the flash section of the vacuum tower. Overhead product from the vacuum tower is a lube distillate, viscosity depending on the asphalt product being desired. Asphalt or flux is pumped from the bottom of the vacuum tower, a level being held by a liquid level control.

A reduced pressure is maintained in this tower to facilitate the distillation of lighter fractions at as low temperature as possible, in order to eliminate the decomposition of lubricating oil distillate and asphalt bottoms. Considerable steam is injected into the vacuum tower near the base which assists in vaporizing the lube distillate by reducing the partial pressure of the oil vapors. This process is known as wet vacuum distillation and has proven most efficient for reduction of asphalt crude to various grades of paving asphalts and roofing fluxes.

Consistency of the asphalt residue is controlled by the temperature reached in the furnace, amount of vacuum maintained, reflux added to the vacuum tower and amount of steam used. This type of operation is flexible, making it possible to produce any grade of product from the consistency of light flux or binder to lowest penetration grades of paving asphalt, direct from the vacuum tower.

PETROLEUM RESERVES

USE OF DENSITY FACTOR IN PREDICTING NEW OIL RESERVES.—Dorsey Hager, in OIL WEEKLY, vol. 85 (1937), No. 7, pp. 16–18.

In view of the fact that demand for oil is increasing and imposing an urgent need for the opening of new oil fields, the author attempts an answer to the question as to where the new oil is to come from, and how much of it is there. As the basis of his calculations he uses the "density factor," which is the "ratio of producing acreage to total producing (proven?) acreage plus prospective producing acreage in each state." For example, the proven acreage in Arkansas is 67,240, and the estimated prospective oil acres in that state is 10,084,800. Hence the density factor for Arkansas is

$$\frac{67240+10084800}{67240}=156$$

By applying this factor, deduced for each state, according to principles shown in the paper he arrives at the total ultimate production in millions of barrels as shown in the accompanying table.

The picture here presented shows that the total production to Jan. 1, 1935, was 17,588,000,000 bbl., and the estimated reserves as of that date 13,667,000,000 bbl. The expected new future production will amount to 19,504,000,000 bbl. so

that total reserves plus new production shows the figure 33,171,000,000 bbl. as the grand total of all oil supplies in this country yet to be drawn upon. If consumption continues at a rate of 1,000,000,000 bbl. annually, our oil resources will suffice for 33 years, or until 1980. After that we can fall back on coal and oil shale. The figure 50,759,000,000 bbl. represents the total stock of oil underground when the industry first started.

Rank in Area	State	Total Ultimate Production (Million bbl.)
26	Arkansas	997
2	California	10,244
7	Colorado	183
23	Illinois	994
37	Indiana	317
13	Kansas	2,028
36	Kentucky	220
30	Louisiana	1,864
22	Michigan	668
3	Montana	1,416
4	New Mexico	2,787
29	New York	180
33	Ohio	757
17	Oklahoma	6,885
32	Pennsylvania	1,293
1	Texas	17,810
40	West Virginia	463
8	Wyoming	1,603
	Total	50,759

USES OF PETROLEUM

Does Stored Diesel Fuel Deteriorate? R. Heinze and M. Marder, in BRENNSTOFFECHEMIE, vol. 18 (1937), No. 6, pp. 117–121.

Question of possible changes in the quality of stored Diesel fuel is sometimes raised, but it does not appear that much serious work has been done on the problem. The authors stored well-refined Diesel fuel oil of mineral origin for 500 days. It was found that the density, the parachore and the boiling point had undergone modifications, but the deviations were still within the limits of analytical error. The case was somewhat different with synthetic Diesel fuels obtained from German lignites, especially where the refining had not been thorough.

Where the physical constants of a Diesel fuel become modified, the fact is due to the reactivity of high-boiling impurities, chiefly asphalts and other substances that could be removed by a suitable refining process. The more of these impurities are present the more likely is the oil to become foul in storage, but this relation is still only an approximate one.

Is Ethyl Gasoline Dangerous? A Recent Opinion.—Anon, REV. PETROL., No. 727 (1937), pp. 371–374.

The writer summarizes reports of investigations conducted by French medical officers on toxicity of tetraethyl lead, with special reference to its use in aviation services. This substance, which is the most active and manageable of all anti-knock agents now in use, is admittedly dangerous to health under certain conditions. Such danger may arise from four principal sources:

In manufacture: This was initially highly dangerous, but the danger has now been almost completely obviated by precautionary measures and use of closed vessels.

In mixing: Tetraethyl lead has to be diluted with various components to produce the "ethyl fluid" for mixing with gasoline. Danger is again avoided by precautionary measures and constant medical surveillance of workmen.

Handling of ethyl gasoline: When diluted with gasoline in authorized proportions the mixture does not seem to present any danger, on condition that it is used only for fuel purposes. However, tanks which have long served as containers of ethyl gasoline may accumulate suspensions of tetraethyl lead in quantity sufficient to poison the men who clean such tanks.

Contamination of atmosphere: Fears regarding contamination of air in garages or streets do not appear justified. The quantity of lead taken with the air into the lungs under ordinary conditions is insufficient to produce lead poisoning. In any case the carbon monoxide in the exhaust gas makes the air irrespirable long before the amount of lead could reach toxic concentration.

Lubrication of Hypoid Gears, A Major Problem for Refiners.—J. P. O'Donnell, in OIL & GAS JOUR., vol. 35 (1937), No. 45, pp. 45–50.

By widespread use of hypoid gears in 1937 automobiles the automobile industry has imposed a serious problem on the oil industry; normal mineral oils are no longer capable of protecting such gears, which require an ultra-powerful, specially designed lead active-sulphur lubricant. The oil industry is hardly ready for such a change. The matter of appropriate specification tests is not yet settled, and it is apparent that these tests must be severe; temperatures at one point in the gear action have approximated melting point of gear surface. The most common testing machine is characterized as "more of an anti-weld test than a lubricant test", the result being rather a proof of the degree of chemical activity of the end-point agent employed.

PETROLEUM SUBSTITUTES

A Study of Anti-Rust Materials in Sugar Solutions.—F. Baerts, P. Delvaux and S. Lange, in SUCRERIE BELGE, vol. 56 (1937), Nos. 14–15.

It has been stated, on what appears to be good authority, that a thick sugar syrup has a lubricating quality superior to that of mineral oil. A possible objection to the practicality of this suggestion is that sugar solutions necessarily are made with water, and water in long contact with iron or steel would promote corrosion.

Without attempting to settle the question as to actual lubricating qualities of sugar solutions, the authors made a three-year study of substances that, when added to a sugar solution, would inhibit a rusting effect of such solutions on steel. The method was to place a number of S.K.F. roller bearings or iron nails in the prepared solutions which were maintained under various conditions at 50–55 deg. C. The rate at which the metal was corroded was noted, from which calculations were made of the useful life of the metal under those conditions.

Among the substances tested for their rust-inhibiting properties in sugar solutions the most effective were found to be organic and inorganic picrates, picraminates, and picrate plus cresol. The calculated life of the metal is stated to be in excess of five years. On this basis it is concluded that the matter is well worth further study.

Olive Oil as Motor Lubricant.—M. Peru, in ANN. OFF. NATIONAL COMBUST. LIQUIDES.—Vol. 11 (1936), p. 1071.

On road tests in Tunis with a mixture of 80 percent mineral lubricating oil and 20 percent olive oil in a Peugeot 402 there was found much gum formation and corrosion; consumption of oil was greatly increased in comparison with pure mineral oil, and the engine gave off a distinct odor of burnt grease.

A Citroen 7 CV with 80 percent of Mobiloil and 20 percent of second grade olive oil containing less than one percent of free fatty acid showed excessive corrosion of the cylinder walls. Since these relatively small additions of olive oil gave such unfavorable results the proposition to subsidize olive oil by enforced mixing with mineral oil has been abandoned.

PETROLEUM ECONOMICS

Future of Petroleum Exploration in the United States.—E. DeGolyer, before AM. ASSOC. PETROLEUM GEOLOGISTS, Los Angeles, March 1937.

At the present rate of consumption of petroleum products in the United States the equivalent of ten to twelve 10,000,000-bbl. fields is required annually to keep proved reserves, which have never been too great, in balance with consumption. For comparison it is shown that annual consumption now amounts to more petroleum than was produced in the first half of the industry's life. The United States consumes annually more than the equivalent of five or six Spindletops; two or three Long Beaches, Cushings, Salt Creeks, Bradfords, or Oklahoma Cities; one and a half Conroes, Yates or Kettleman Hills, or a third to a fourth of a phenomenal East Texas pool. All the oil produced in Pennsylvania since the beginning of the industry, or all the oil produced in the Gulf Coastal Plain of Texas and Louisiana, is sufficient to meet only one year's requirements.

The entire past production of California would meet the national requirements for only five or six years at present rate of consumption. In fact, all oil produced in the 77-year life of the industry would cover only the requirements for the next 10 or 15 years (if the rate of consumption remains stationary).

Since we can only speculate as to the amount of oil yet to be discovered common sense indicates that there is no guarantee that the present rate of production can continue and wise conservation should be considered. Imports of foreign oil should be encouraged if it can be done without too much dislocation to domestic industry; American companies should be encouraged to secure foreign reserves, the technique of prospecting, producing and refining oil should be advanced, and motor fuel used more efficiently. The author adds that we should refrain from the less desirable uses of oil, such as burning it for fuel, but hardly expects that the suggestion will be welcomed.

There remains the ever present necessity of looking for new reserves. The author makes the point that this work will be best promoted if all the oil companies create separate organizations for prospecting, which will be relieved of all other duties. The financial health of any oil company depends on its reserves and the chief means of preserving that health is more, and especially better, exploration.

GENERAL

Corrosion Resistant Metals.—F. N. Speller, in REFINER, vol. 16 (1937), No. 3, pp. 105–107.

After a discussion of metals and alloys in relation to their use in situations where they will be exposed to corrosion, the author concludes that it is unlikely that we shall find one metal or one general remedy for all kinds of corrosion. The

metal and environment must be mated so as to live together peaceably, at least until the owner gets a reasonable return on his investment. This is essentially an economic problem, the answer to which may be to let the structure alone and recondition when necessary, as is often the practice in buried pipelines; to apply a coating of a more resistant material; to condition the environment so that it will be less active; or to select the metal or alloy best adapted to the particular conditions of service at the lowest consistent cost. Structural design, regulation of environment, and care of metals are important factors in their life. It should be remembered that metals are, in a way, quite like human beings; although they are susceptible to unfavorable environment, their resistance can be built up by inoculating them with alloying elements and by keeping their surfaces reasonably clean and free from foreign deposits. As the useful life of any metal is determined mainly by the film-building properties of both the environment and the metal, and as metals have to live under so many conditions of service, it is extremely improbable that any one metal can be made at reasonable cost that will meet all the common conditions of service. The problem of the engineer, therefore, is to select the metal that will best serve any specific purpose at the lowest ultimate cost. Too much attention may be given to first cost.

Research and Development Activities in the Standard Oil Company (N.J.) Interests.—W. C. Asbury and David A. Shepard, in JOUR. INST. PETROLEUM TECHNOLOGISTS, vol. 23 (1937), No. 161, pp. 192–196.

Since its incorporation 65 years ago Standard Oil Co. of N. J. has been engaged continuously in research and development; the authors explain in a general way how the organization is solving new chemical and engineering problems while endeavoring to keep up with an expanding and shifting market.

The S.O.C. (N.J.) is a holding company with several hundred subsidiaries and affiliates. Problems peculiar to each major operating unit are studied in separate laboratories owned and operated by these organizations. In addition, all these operating companies are served by a commonly-controlled central staff organization known as Standard Oil Development Co. which coordinates the scientific and technical as well as patent activities of the operating units, besides certain commercial and patent business of its own. The development company does most of the pioneering research work of the group, besides service work for units that do not have their own laboratories.

The main research plant is at Bayway, N. J. Here are the Esso Laboratories that are engaged in testing new processes and products, especially motor fuels and lubricants, with emphasis on the utilization of refinery by-products. Equipment of this laboratory is elaborate and includes full sized units. Another group at Bayway is studying refinery processes, using semi-factory scale equipment; about half the work of this laboratory is on problems raised by the various refineries, the other half is mainly on research and development.

There is also a general engineering department with complete refineries, storage plants and equipment of all sorts for the study and design of stills, towers, resistivity of materials, etc. A process engineering department conducts plant tests on new and old processes. Development of new processes, including oil hydrogenation developments, are studied in the Baton Rouge laboratories. The Sarnia laboratory in Canada is active in the study of dewaxing and asphalt manufacture and the phenol extraction process. All these American activities are more or less duplicated on a smaller scale in European laboratories operated by the company or its affiliates. Aside from the laboratories engaged in development work are the standard inspection laboratories that deal with all questions relating to products quality. Finally, contact with market requirements is maintained by a sales engineering department.

Besides research under its direct control the company frequently turns problems over to outstanding specialists in the academic world, supplying them with funds, material and assistants, and plant employees are encouraged to submit new ideas to the patent department.

A fundamental principle in the direction of the research and development programme of the Jersey Standard interests has been the recognition of the importance of the contributions to petroleum technology made by independent scientists and technologists. A fixed rule which is binding upon every responsible technical executive of the Jersey interests is that he must keep an open mind on the potential value of the work of the independent technologist. As a result of this policy there have been developed many mutually advantageous affiliations by the S.O.C. of N.J. interests with individuals and groups, both inside and outside their own industry in relation to new inventions and scientific advances.

Experimental Research on Iraq Petroleums.—M. G. Levi, A. Mariotti and E. De Bartholomaeis, in RIV. ITAL. PETROLIO, vol. 5 (1937), No. 47, pp. 3–7.

The investigation relates to crude oils from one 3,050-bbl. and one 10,000-bbl. well of B. O. D. Co. Ltd., on the right bank of the Tigris, near Mosul. These oils are of poor quality and require extensive refining; the heavy lube fraction is absent, cracking yields 60 percent of gasoline and kerosene, but these products also require extensive refining. Yields of 80 to 85 percent can be obtained by hydrogenation. The crude contains 1.8 percent sulphur which adds to refining problems.

Characteristics and Yields of North Louisiana Crudes.—A. W. Trusty in OIL & GAS JOUR., vol. 35 (1937), No. 45, pp. 119–120.

North Louisiana has about 4,300 producing oil and gas wells with an average oil production of about 81,000 bbl. per day. Although a small part of the oil is naphthene base or intermediate-paraffin base, the majority of the production is paraffin base oil. Sulphur content of the oils is low, even on the naphthenic crudes.

The majority of straight run gasolines require a blend with natural gasoline in order to meet the volatility specification of commercial gasolines. Due to the low sulphur contents, the gasolines rarely need chemical treatment to meet corrosion, doctor or sulphur specifications.

High yields of kerosene are realized. After doctor treatment kerosenes have a low sulphur content, are stable to storage, and have unusually good burning qualities.

Lube oils can be produced from Rodessa, Caddo, Bellevue and Urania crudes. Only small yields are obtained from the other crudes. A high quality asphalt can be produced from Bellevue, Caddo and Urania crudes.

Organization of Research in the Petroleum Industry.—J. H. Vermeulen, in JOUR. INST. PETROLEUM TECHNOLOGISTS, vol. 23 (1937) No. 161, pp. 179–191.

The paper deals with the organization of the physical, chemical and related mechanical research work in a central research laboratory in the petroleum industry. It is held that such research work should be carried out *centrally*, and that, besides research work, there is a great deal of service (routine) work to be done. The principal conditions (position, sources of information, scientific contact and contact with the world of practical application) for the satisfactory functioning of a laboratory of the kind are described.

A form of organization (with the work divided into routine and ordinary applied research on the one hand and pioneering applied research and pure research on the other) is indicated in which, in the author's opinion, the conditions described have the best chance of success. The paper, which was based on the experiences of the Royal Dutch-Shell group, concludes with remarks on reporting and supervision.

A Study of the Devoli (Albania) Crude Oil.—M. C. Levi and A. Moriotti, in RIV. PETR. ITAL., vol. 5 (1936–37), Nos. 42–47.

The crude petroleum of the Devoli district, which is the principal producing area of Albania, is highly bituminous. When distilled under partial vacuum (100 mm.) it yields a total of 60 percent distillate containing 12 percent of light and 6 percent of heavy gasoline, and 37 percent of bitumen; when destructively distilled under atmospheric pressure it gives 16 percent of coke and a total of 82 percent of distillate of which about 50 percent boils below 280 deg. C.

Excellent results have been obtained by a primary distillation followed by a steam distillation and a high-vacuum treatment of the vapors; the products are 20 percent of benzene boiling up to 200 deg. C., 7 percent of kerosene, 8 percent of gas oil, 30 percent of lube oils and 31 percent of bitumen which is of an excellent grade for road construction purposes. Attempts to hydrogenate the bitumen have been fairly successful.

BOOK REVIEW

Methods of Petroleum Analysis (Collection and Comparison of Methods in Practical Use in Various Countries). Part I, issued as Monograph No. 7 of the AUSTRIAN PETROLEUM INSTITUTE, Vienna, and published by VERLAG FUER FACHLITERATUR, Vienna XIX; 168 pages, with 13 large tables. RM 10.

The case often arises where an oil shipper needs information as to what methods will be employed for testing the product by the foreign customer, and there is also the case where an importer wishes to know by what methods an oil product was tested before it left the hands of the producer.

It is the object of this book to make information of this kind easily available; the author has assembled under one cover the more common testing methods used on commercial oil products in all countries that come into consideration. Order of arrangement is such that any point of interest can be quickly run down. Only commercial tests are considered; methods of chiefly scientific interest are excluded. References are given to official documents containing the prescribed methods.

This is a book to be owned and used by all oil shippers and importers. It is also worth a place in the oil works laboratory, if only for the side by side comparison of different methods. The present text is in German, but it is announced that an English edition is under way. Beyond that, the Austrian Petroleum Institute is on record as favoring international cooperation for reproducing it in other languages.

WORLD OIL PRODUCTION—Official Figures

All figures furnished direct to WORLD PETROLEUM by governments, except where otherwise specified—Table revised monthly

(Figures in U. S. Barrels—Conversion ratio 7 bbl. = 1 ton)

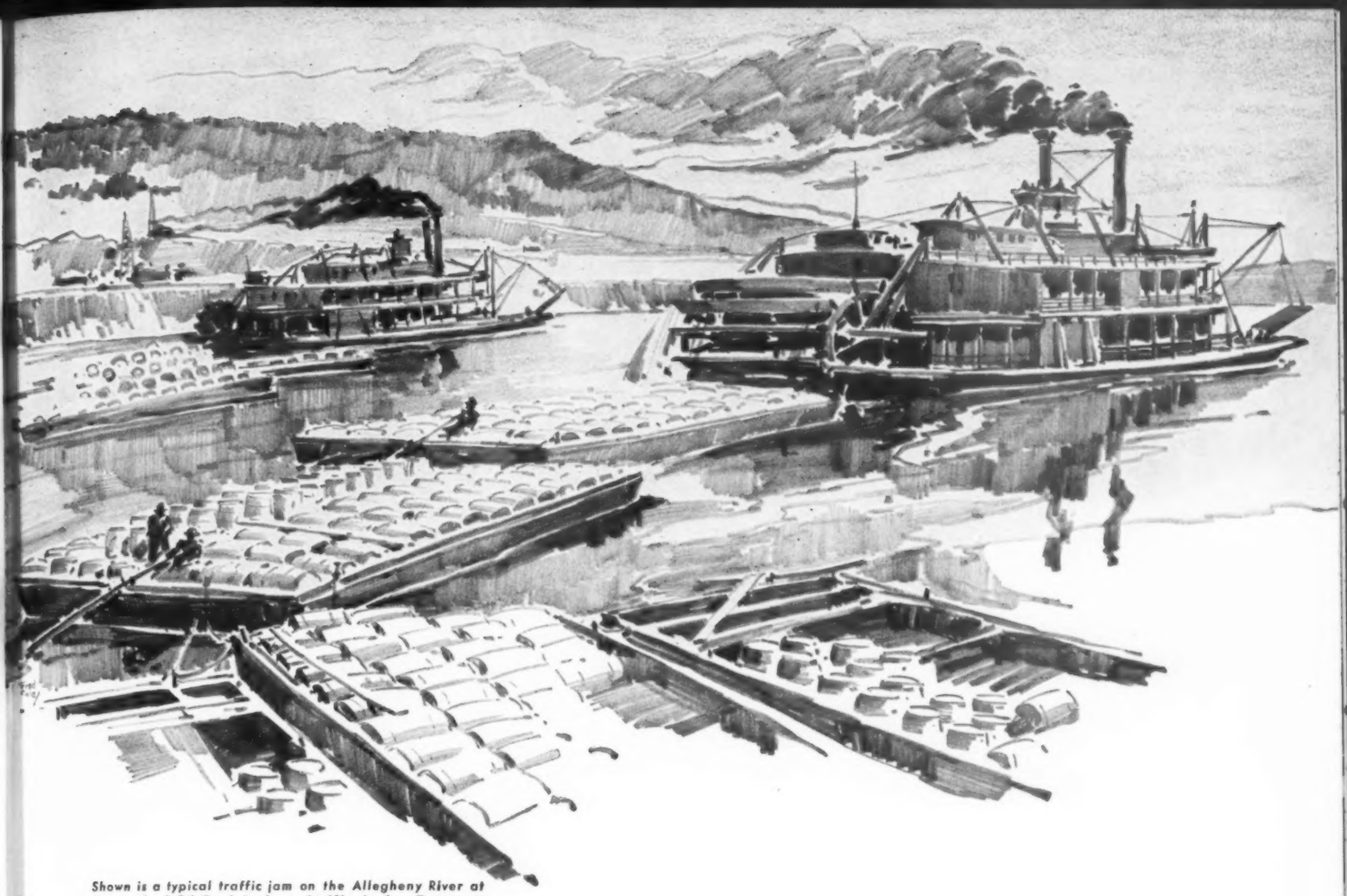
Country	May 1936	June 1936	July 1936	August 1936	September 1936	October 1936	November 1936	December 1936	January 1937	February 1937	March 1937	Provisional Figures, April, 1937
United States	93,739,000	90,185,000	92,087,000	95,090,000	90,972,000	95,795,000	91,018,000	97,652,000	98,567,000	93,173,000	106,724,000	107,609,000
Russia	16,454,200	15,955,100	16,231,600	15,737,500	14,936,600	16,118,900	16,019,700	16,412,900	15,476,300	13,947,500	15,800,000[1]	15,900,000
Venezuela	13,732,933	12,486,600	14,566,510	14,632,737	14,626,073	13,888,287	14,307,650	8,452,626	9,888,298	13,583,024	15,584,002	13,018,000
Roumania	5,568,000	5,563,000	5,606,000	5,585,000	5,254,000	5,224,000	4,982,000	5,050,000	4,768,000	4,217,000	4,595,000	4,527,000
Iran [2]	5,376,000	5,061,000	4,872,000	5,117,000	4,487,000	4,704,000	4,620,000	4,963,000	5,250,000	4,417,000	5,866,000	5,015,000
Netherland India	3,721,613	3,549,417	3,725,491	3,715,887	3,731,973	4,059,426	4,139,954	4,190,578	4,009,355	3,768,975	4,148,732	3,976,000
Mexico	3,235,255	3,167,300	3,179,614	3,773,503	3,768,855	3,235,224	3,204,007	4,259,733	4,233,635	3,923,000[1]	4,307,952	4,015,000
Iraq [3]	2,467,136	2,473,660	2,440,669	2,479,428	1,881,782	2,097,564	2,214,954	2,207,954	2,476,698	2,240,119	2,542,883	2,501,778
Colombia [3]	1,598,544	1,529,901	1,585,345	1,553,606	1,575,273	1,600,288	1,537,683	1,641,636	1,668,490	1,617,441	1,622,226	1,654,000
Peru [4]	1,500,485	1,452,306	1,524,303	1,527,072	1,478,482	1,507,433	1,445,605	1,492,023	1,448,545	1,321,989	1,464,979	1,412,000
Argentina	1,231,354	1,140,080	1,286,536	1,293,283	1,323,730	1,306,784	1,356,396	1,356,396	1,317,000[1]	1,190,000[1]	1,317,000[1]	1,267,000
Trinidad	1,066,728	1,078,186	1,121,583	1,108,969	1,126,420	1,179,611	1,154,093	1,231,365	1,263,456	1,157,408	1,287,097	1,301,260
British India	827,762	778,947	817,364	815,415	791,217	730,860	778,617	809,218	788,000[1]	730,000[1]	745,000[1]	688,000
Bahrein	340,104	295,567	564,607	780,265	422,799	209,086	419,643	619,910	730,064	549,260	672,000[1]	650,000
Poland	331,100	287,000	294,000	301,000	294,000	301,000	294,000	301,000	295,400	273,000	298,000[1]	299,000
Brunei	225,890	206,780	266,700	275,310	257,040	294,070	294,560	322,210	354,480	327,600	125,650	269,000
Germany	244,552	256,613	272,699	257,859	255,556	277,158	265,650	279,545	265,531	233,366	245,007	248,000
Japan	203,071	198,387	206,284	221,139	207,260	200,528	202,385	212,326	219,410	194,037	207,423	205,000
Ecuador	163,855	156,703	163,714	160,914	158,857	168,892	163,870	175,918	180,058	160,675	180,727	181,258
Sarawak	134,610	128,660	130,200	129,150	122,010	127,330	122,920	128,240	125,440	114,380	139,650	126,000
Canada [5]	114,297	114,050	139,940	139,789	135,623	137,004	129,152	139,701	141,078	153,906	175,575	137,000
Egypt	107,989	106,694	106,260	102,620	98,812	102,109	97,755	98,672	99,589	86,842	93,499	93,000
France [1]	44,981	43,530	44,981	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000
Others [1]	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
Total	152,504,459	146,289,481	151,299,400	154,917,446	148,025,362	153,384,554	149,188,194	152,215,951	153,685,827	146,799,522	168,262,402	166,222,304

[1] Estimate. [2] Anglo-Iranian Oil Co. figures revised; fuel oil returned to the ground has been deducted. [3] International Petroleum Company's figures. [4] International Petroleum Company and Lobitos Oilfields Ltd. figures. [5] Includes natural gasoline production. [6] Exports.

Russian Sakhalin included with Russia. Japanese Sakhalin included with Japan.

Official Crude Oil Production Figures for 1932 to 1937

	Daily Average to Apr. 30 1937	Daily Average 1936	Total to Apr. 30 1937	Total 1936	Total 1935	Total 1934	Total 1933	Total 1932
United States	3,304,616	3,001,410	406,073,000	1,098,516,000	996,596,000	908,065,000	905,656,000	785,159,000
Russia	503,531	523,754	60,423,800	191,694,100	176,688,100	168,648,700	149,311,000	149,725,000
Venezuela	433,944	436,900	52,073,324	159,905,526	154,021,599	140,784,805	120,882,802	119,596,512
Roumania	150,891	173,527	18,107,000	63,511,000	61,150,000	62,006,000	50,971,200	50,491,205
Iran	168,825	177,424	20,548,000	59,386,833	52,413,879	52,761,604	48,581,280	45,122,455
Netherland India	133,525	122,030	15,903,062	44,662,857	42,569,625	42,289,408	38,512,663	39,584,027
Mexico	137,330	112,095	16,479,587	41,026,724	40,234,902	38,167,022	33,904,882	32,802,285
Iraq	81,345	74,484	9,761,472	27,261,087	24,850,924	7,935,657	1,200,000	1,200,000
Colombia	55,124	51,246	6,562,109	18,756,110	17,617,645	17,340,724	13,157,127	16,834,956
Peru	47,062	47,415	5,647,513	17,353,778	16,835,206	15,936,937	13,923,281	9,899,266
Argentina	42,425	42,294	5,091,000	15,479,692	14,317,500	14,045,652	13,759,565	13,166,900
Trinidad	41,743	36,167	5,009,221	13,237,075	11,669,792	10,894,363	9,560,039	10,023,780
British India	24,591	26,071	2,951,000	9,541,966	9,227,496	8,997,399	8,721,655	8,600,312
Bahrein	21,676	12,725	2,601,324	4,644,635	1,264,807	285,072	31,377	902
Poland	9,328	9,773	1,119,400	3,577,000	3,612,000	3,697,617	3,858,085	3,905,230
Brunei	8,972	8,639	1,076,730	3,162,040	3,162,614	2,673,041	1,963,661	1,233,925
Germany	8,268	8,503	991,904	3,112,200	2,991,800	2,222,500	1,670,200	1,607,900
Japan	6,882	6,515	825,870	2,384,378	1,848,656	1,484,962	1,337,761	1,575,333
Ecuador	5,856	5,252	702,812	1,922,215	1,725,354	1,655,062	1,622,624	1,573,857
Sarawak	4,212	4,253	505,470	1,556,660	1,811,297	1,948,044	2,289,472	2,274,043
Canada	5,229	4,110	627,559	1,504,287	1,447,204	1,422,869	1,162,541	1,044,412
Egypt	3,108	3,341	372,930	1,222,865	1,215,606	1,479,037	1,591,495	1,742,370
France	1,500	1,459	180,000	534,063	529,664	552,000	552,000	552,000
Others	2,500	2,459	300,000	900,000	900,000	861,000	432,000	432,000
	5,202,483	4,891,846	633,934,135	1,784,853,091	1,640,701,671	1,506,154,475	1,424,652,710	1,298,147,670



Shown is a typical traffic jam on the Allegheny River at the mouth of Oil Creek in the early 60's. In the effort to get oil to market, boats, barges and rafts were loaded with crude oil—dams were opened to create a rush of water—often resulting in loss of cargoes and life. It is estimated that over 1,000,000 barrels of oil were lost in this frenzied effort to ship oil.

Dependent on plodding teams and sluggish barges, early oil producers struggled frantically to serve their customers. Progress has changed all that. For example, Dowell is particularly proud of its transportation equipment and service. Its fleet of fast trucks and cars goes anywhere—any time. To date, in treating over 9,000 wells, Dowell equipment has travelled over 4,500,000 miles and transported Dowell *Inhibited* Acid totalling millions of gallons.

ATTENTION DRILLING CONTRACTORS

Dowell's latest advance—Dowell Inhibited Heavy Acid—assures greater efficiency in loosening stuck drill pipe. Acid heavier than drilling mud is, in many cases, essential for successful freeing of pipe stuck at the bottom of the hole. Write to any Dowell station for The Acidizer, "Loosening Stuck Drill Pipe."

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OIL AND GAS WELL CHEMICAL SERVICE

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Minnie Esso—an unassuming cat despite her high station.

"Minnie of The Standard Oil— Gee, but you're a lucky goil!— — —"

MINNIE ESSO, official mouse catcher for Standard Oil Company of New Jersey at the Bayonne refinery laboratory, was the only employee who did not receive an increase in monthly earnings under the firm's recent pay increase for low-salaried employees. Minnie, a three-year-old cat and mother of four little ones, has been the source of considerable anxiety on the part of Walter C. Teagle, Jersey Standard's president, who wrote to Dr. E. W. Dean, director of the laboratory, to determine what provision had been made for her declining years under the Social Security Act and what benefits she can hope to receive under the company's decision to award a flat monthly increase of $15 to those employees receiving under $1,800 per year.

Minnie's salary of $3.20 per month has been in the company's books for the past twenty months.

Dr. Dean duly appointed a committee to investigate Minnie's eligibility for old age pension, but was forced to admit to Mr. Teagle that while he would be glad to increase her stipend, "You can't very well give a cat more milk than it will drink." She has so efficiently rid the laboratory of rodents that milk and canned salmon are the only items remaining on her diet. Minnie's dependents have never been a problem, and should the cost of living rise, or inflation become a reality, her pay will be increased to assure her a full dinner pail at all times.

Wide publicity given to Minnie Esso as being the only feline to receive a regular pay check (cashed by E. H. Bengough, chief clerk, at the grocery store) has already brought complications. An elegant but slightly lazy male cat named "Nicky" sent her a proposal of marriage, adding that "as you have a good job with the Standard Oil, I am sure we could manage very nicely."

ROTARY HOSE

A NEW type wire reinforcement for rotary hose has recently been developed which has increased the burst-resistance of the hose many hundred pounds. It consists of multiple plies of extra heavy duck and two or three plies of a radically new type wire spiralled in opposite directions by a special method. Each ply of wire is embedded in rubber and carefully insulated from the other by a ply of rubberized duck. The cover is of selected, best abrasive-resisting rubber, 50 percent thicker than any other cover used before.

Reinforcement extending back 36 ins. from the ends consists of an extra ply of wire and numerous plies of heavy duck to take the strains of couplings, vibration, bends and high pressure.

GULF EXPORT PRICES FOR MAJOR OIL PRODUCTS

Products		Cents per Gallon				
		Apr. 14	Apr. 21	Apr. 28	May 5	May 12
Gasoline:	U. S. Motor	5⅞	5⅞	5⅞	5⅞	5⅞
	64/66–375 E.P.	6⅛	6¼	6¼	6¼	6¼
	59 Octane and below	5¾	5⅞	5⅞	6	6
	65 Octane and above	6⅛	6¼	6¼	6⅛	6⅛
Aviation Gasoline (Gulf Export)	73 Octane, cargo lots* f.o.b. Gulf port.	9½	9½	9½	9½	9½
Kerosene:	44 w.w.	5	5	4¾	4¾	4¾
	41–43 w.w.	4⅝	4⅝	4⅛	4⅛	4⅛
	41–43 p.w.	4⅝	4¾	4⅛	4⅛	4⅛
Gas Oil:	26–30 translucent	3¾	3⅞	3⅞	3⅞	3⅞
	30 plus translucent	3⅞	4	4	4	4
Fuel Oil:	Grade C Bunker (bbl.)	1.00	1.00	1.00	1.00	1.05
	Cargo lots	.95	.95	.95	.95	.95
	Diesel oil	1.65	1.65	1.65	1.65	1.90
Lubricating Oil:	Bright Stock No. 8	32	32	32	32	32
	Bright Stock No. 6½	31½	31½	31½	31½	31½
(New York Export Market)	600 Warren E.	26	26	26	26	26
	600 Unfiltered s.r.	24	24	24	24	24
	650 Unfiltered s.r.	25½	25½	25½	25½	25½
	600 Flash s.r.	26½	26½	26½	26½	26½
	630 Flash s.r.	31	31	31	31½	31½
	Neutral 200 No. 3	32	32	33	33½	34½
	Neutral 150 No. 3½	28	28	28½	29	30
	Red oil 500 No. 5–6	7½	7½	7½	7½	7½
	750	8¾	8¾	8¾	8¾	8¾
So. Texas:	1200	9½	9½	9½	9½	9½
	Pale oil 500	7⅝	7⅝	7⅝	7⅝	7⅝
	750	8¾	8¾	8¾	8¾	8⅝
	1200	9½	9½	9½	9½	9½
Crude Oil:	East Texas delivered at Gulf port for export (per bbl.)	$1.52	$1.52/54	$1.52/54	$1.52/54	$1.52/54
	Venezuela (per bbl.)	1.05	1.05	1.05	1.05	1.05
	Trinidad (per bbl.)	.90	.90	.90	.90	.90
	Panuco (per bbl.)	1.35	1.35	1.35	1.35	1.33

Freight Rates

	Dirty	Clean	Dirty	Clean	Dirty	Clean	Dirty	Clean	Dirty	Clean
	Shillings per Ton									
Gulf—U. K. or Continent	36/-	36/-	29/-	36/-	29/-	36/-	29/-	33/6	27/6	31/6
California—U. K. or Continent	no booking									
Aruba—U. K. or Continent	32/6	33/6	37/-	34/-	37/-	34/6	37/-	34/-	29/-	33/-
	Cents per Barrel									
California—North Atlantic	no booking									
Gulf—North Atlantic	48	37	48	35	48	35	35	50	45	50
Venezuela—North Atlantic	47	—	44	—	44	—	42	—	35	—
Tampico—North Atlantic	57	—	52	—	52	—	50	—	45	—

* Changed basis: Figures previously reported (tank-car f.o.b. refinery) were nominal prices. Above figure is based on last actual transaction prior to date given.

MOST SULPHURIC ACID EQUIPMENT IN REFINERIES TODAY IS OBSOLETE!

FOR the regeneration of sulphuric acid from acid sludge, separating systems aided by concentrating plants were at one time all right. But in today's scheme of things, there is no place for a procedure yielding only weak dirty acid that must be purified and concentrated in separate stages with excessive labor expense and loss of valuable material and time all along the line. Nor is there any other place in the refinery where modernization will effect greater economies.

CHEMICO Acid Sludge Conversion Plants not only produce a top-quality acid supply in one compact group of cheaply operated equipment, but as the only residue, petroleum coke, has high fuel value, everything in the sludge is utilized, and waste disposal, with its non-productive labor expense and pollution risks, is completely eliminated.

What the CHEMICO Sludge Conversion Plant Does

A CHEMICO Sludge Conversion Plant produces clean clear acid, directly from raw unseparated acid sludge. The acid produced may be 98% H_2SO_4 or any desired higher strength and requires no further purification or concentration.

The process is simple. The raw sludge is decomposed by heat to strong sulphur-dioxide gas and a dry granular coke. The gas is scrubbed clean of impurities (with recovery of the oil content) and converted into sulphuric acid in an acid production unit employing long-lived vanadium catalyst. Operation is continuous and the equipment is sealed throughout to prevent escape of fumes. *Sludges that cannot be separated or utilized profitably by former processes may be satisfactorily converted into strong acid by this CHEMICO Conversion Process.*

Every CHEMICO Conversion Plant is designed to meet the sludge conditions and acid requirement of the individual refinery, and performance is guaranteed in definite figures. Chemical Construction Corporation designs and erects the entire plant, assuming full responsibility for all apparatus and proper co-ordination, and delivers the completed plant with its crew trained for full capacity operation. Acceptance is asked only after proof by test that every guarantee is well met.

Write also for booklet "CHEMICAL PLANT CONTROL DATA"

88 Pages of information on sulphuric acid, etc., including recommendations for analyses, tables of properties, curves and charts for calculations, and other helps for industrial chemists.

Sent free to refinery executives and chemists who apply on company letterhead and state official position.

If your acid requirements are 20 tons or more per day, we can show you possibilities that are too important to neglect. Preliminary conference involves no obligation

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CHEMICO PLANTS are PROFITABLE INVESTMENTS

U. S. S. R.

Official Figures for Soviet Oil Operations

	Crude Production (bbl.)	Daily Average (bbl.)	Runs to Stills (bbl.)	Drilling (feet)
January	15,476,300	499,233	13,977,000	448,308
February	13,247,500	473,029	12,167,400	359,317
March	15,800,000	509,608	13,900,000	522,100
April	15,900,000	530,000	14,200,000	512,000
Total 4 months, 1937	60,423,800	503,533	54,244,400	1,841,725
Total 4 months, 1936	63,377,300	523,780	54,666,700	2,255,816
Total 1936	191,694,100	523,754	173,408,200	6,958,916
Total 1935	176,688,100	497,713	146,705,000	4,858,465
Quota 1936	213,500,000	584,931	175,000,000	7,100,000
Quota 1935	212,310,000	581,672	171,500,000	5,214,000
Quota 1937	225,120,000*	617,000	200,000,000	9,240,000

* Revised from 241,500,000 bbl. Crude conversion: seven bbl. = one ton.

THE RECENT Soviet political trials, in which many heads of Russian industries implicated themselves or were implicated by their fellows as Trotzkyists and hence saboteurs, have resulted in an epidemic of accusations against the industrial heads and lesser officials which has naturally reflected upon the oil industry as well. Failure to live up to plans during recent months has brought severe consequences; mudslinging has begun and already many at Baku, Grozni and elsewhere have been hit. Among those mentioned were Rosenoer of Grozni, Slutzki, head of Baku, and, to a certain extent, Barinov of Glavneft, Moscow. S. Ganshin, former head of Glavneft and later head of the Soviet Eastern oil base at Ishimbayevo, has been removed and replaced by I. Oparin, formerly of Azneft (one-time representative of Napthsyndicate in New York, and after returning to Russia connected with A. Serebrovsky at the Gold Trust). Serebrovsky himself became vice-commissar for Soviet Heavy Industries, under Mezhlauk. Prozumentic, head of Baku refineries, was removed as a Trotzkyist, while Peterson, former head of production at Baku and later head of Molotov oilfields, was also removed, as was Bortz, head of Kergezneft, Baku. These latter two, together with Danielani, Ginsburg, Markayan, and many others, were mentioned as saboteurs. The hero of yesterday is the traitor of today—he is demoted or discharged and his name disappears, perhaps forever, from list of builders of socialism. Those who undertook responsibilities become saboteurs if their authorized plans fail. Personal malice may cause accusations while friends deny them for fear of being implicated.

ZA INDUSTRIALIZATIU, in recent editorials and reports from staff correspondents, states:

"At a public hearing at Baku in which more than a thousand oil operators had participated A. Serebrovsky had made a speech in which he pointed to sabotage and willful damage which was done to drilling and production. He quoted the Ordzonikidze fields of Baku, where 60 wells were drilled and completed but only 12 mastered for production. Saboteurs, he said, are also active in the division of supplies and quoted instances where supplies were received in the fields entirely different from those ordered and similar sabotage is taking place at auxiliaries. It is not that such cases were not reported, he said. Adequate complaints were made, but these were overlooked and when repeated or insisted upon the plaintiffs were berated as trouble-makers.

"Another speaker reported how the Shukov-Kapelushnikoff cracking installation was razed. Under test this had yielded a high grade aviation gasoline and Slutzki, persuaded by several Trotzkyist saboteurs, not only himself consented to razing of the plant but also made Barinov consent to it." (Slutzki undoubtedly considered the Kapelushnikov cracking method not sufficiently reliable owing to design of the furnace pipes which carry an inside metal rod to increase the heating surface—aggravating risk of coking.) "Slutzki repudiated the attack by stating that if this plant could produce high grade aviation gasoline so will other more reliable cracking units."

Further accusations were made against Slutzki for having held a meeting at his private quarters to discuss improvements in refining since the meeting was predominated by Trotzky followers and saboteurs such as Prosumentic, Danielani, Ginsburg and Markayan. The accusation was substantiated by the fact that all laboratories were congested with unnecessary tests which leave no room for important experiments.

Accusations were also made against operators who had followed methods which the geologists had advised against, but were ordered by Glavneft under recommendation by Poliakov. These methods had led to search for flowing wells while mechanized production was neglected entirely. It was indicated that Krems, geologist of Glavneft, had warned against Poliakov's and Peterson's plans of operation. Krems was in the right, but Peterson's plans were accepted on merit of his having formerly discovered vast oil lands at Apsheron. When Bortz, of Kergezneft, was implicated as a saboteur his assistant insisted that technical difficulties and irregularities beyond control should not be called sabotage, and it was decided that the liquidation of sabotage cannot be entrusted to men who find courage to defend saboteurs.

At a similar meeting, Rosenoer stated, in defense of Grozni's failure to live up to plans, that this time it was not only Grozni but the entire oil industry that failed and this was due mainly to irregularities in the supply of timber, cement and other materials beyond control of the oil operators. ZA INDUSTRIALIZATIU expressed indignation over such an alibi and wondered how Rosenoer had found sufficient courage to own up that organization was so bad and administration so ineffective that it was unable to bring about Stakhanov tempo in operation.

Many other speakers at this meeting reported concerning damage to machinery and equipment. During February, 17 electric motors were burned through negligence and five more were burned during the first days of March. Nobody seems to care about machinery and equipment. Lubrication of motors is being done with crude oil taken right from any ditch near the wells and the chief engineer of Grozni admitted that the management is too busy with work other than managing the enterprise. Orders from headquarters are given in bureaucratic manner and in unintelligible language. It was further admitted that while drilling at Molgabek showed a speed of about 7,000 ft. per month during the last quarter of 1936 it fell from 4,900 ft. in January, 1937, to 3,600 ft. in February and 2,500 ft. in March. The plan for drilling in January was fulfilled 63.8 percent and in February 54.7 percent, while March and April brought no improvement. Under Stakhanov operations of last year only 5.6 percent of all drilling time was lost in stoppages and this year the losses amount to 41.5 percent.

Under sabotage accusations came also prospecting where breakdowns are hindering drilling at almost all wells. Never before has prospecting in Baku outer regions had at its disposal only four outfits, of which two are damaged. Prospecting plans for the past four months were fulfilled 50 percent and during the year eight new regions are to be opened for production. How can this be done? At Izberbash several gushers one after another had dictated to plan for production of 7,000,000 bbl. in 1937, but of the seven wells in operation only one flows about 1,750 bbl. of crude—the other six yield between 70 and 100 bbl. per day. Lack of equipment, of compressors, or even of a tractor-mounted hoist to mechanize production, and so on, has brought about this state of affairs.

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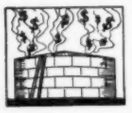

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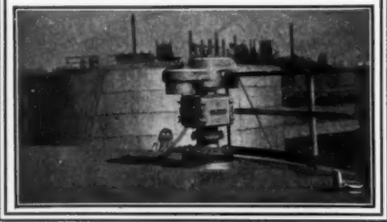

over 11,000 bbl. of crude per day, but yield actually 2,800 bbl. of crude or 15–20 percent of plan. Oil is kept in earthern storage where evaporation is exorbitant and fire hazard great. When production came at Daghestan suddenly no provisions were included in the plans for storage facilities or for a pipeline from the fields to Makhatch Kala and when orders were given to build both pipeline and storage it was found that no projects were made for such construction and it will undoubtedly take time before they are made and approved. Drilling at Daghestan is of poor quality and under present prevailing conditions no more than 20–25 percent fullfilment of planned drilling operations is to be expected. These fields were drilled in 1934 by 45 outfits which achieved a total of 293,-700 ft. In 1937 under increased speed about 300,000 ft. are to be drilled with only 15 outfits. How will this be accomplished and 7,000,000 bbl. of crude produced under prevailing conditions and indices shown for the past four months is being asked by ZA INDUSTRIALIZATIU.

Some three years ago gushers 13 and 13b had made the Turcoman fields famous. The properties were to be extended in 1937 by adding the Nebitdag field, but recent drilling is not encouraging; the speed fell to 600 ft. per month and the productive portion of drilling time fell from 53 to 45 percent, with breakdowns increasing. Not one well has been drilled to completion. The management has excuses to justify the failure, inasmuch as only low-quality pipes and other poor equipment were at their disposal and verify this by having discussed these shortcomings at conferences. The actual causes, the paper says, are to be found elsewhere. Management is poor, there is no control over equipment available. Pipe, equipment and other supplies are so mixed up together in warehouses that nothing can be found when required. The geology of this region is rather of a complicated nature and requires study and research, but there are no laboratory or other facilities for the purpose on the spot. Every sample has to be sent to Baku and gets lost on the way to or fro. This was in reference to Nebitdag, but the old fields from which Nebitdag was to grow are also mismanaged and produce only 4,200 bbl. of crude per day instead of 8,500 bbl. as was expected and is possible. Instead of mechanizing production by compressors, pumps and gas motors—which are all available—everything is left to fate.

Neftprovodskladstroi has employed help without checking their political reliability and sabotage followed. Building is being done without plans and estimates, wages are not paid in due time, safety regulations are not observed and accidents occur. Buildings were erected too near to river shores subject to inundation. Materials, including fine metals and other supplies, are not kept under control and are stolen. Many employees have a criminal record, some even with ten-year jail records. Some officials employ their own wives as accountants so that everything can be "fixed." Glavneft knows of all this but does not take any steps

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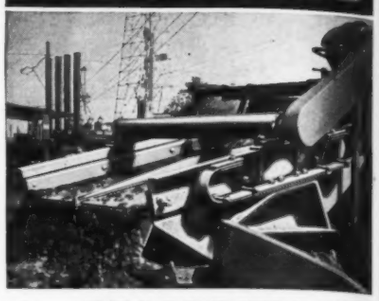

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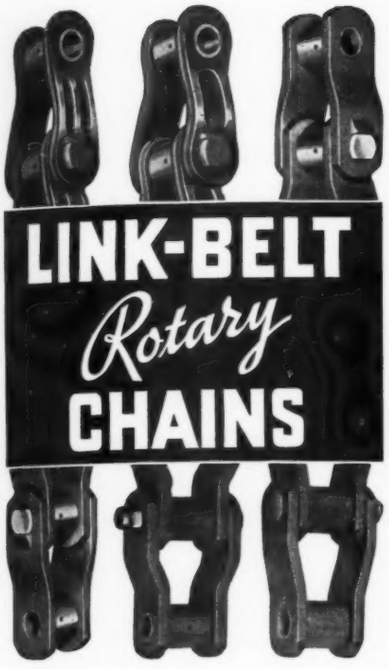

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to remove the shortcomings, states the paper.

No improvement in operation of the Soviet oil industry was effected during April. The disorganization caused by storms and adverse weather during the first two months of the year were of too serious consequence to be counteracted during the following two months and shortcomings of a chronic nature encountered during March and April have hampered progress and only increased arrears of plan and brought aggregate showings in the three main divisions of the industry behind corresponding figures for last year.

Operations of all Soviet heavy industries in general, including the oil industry, January 1st up to April 11th show that labor productivity rose 8.7 percent over the figure for the same period of 1936 and 1.6 percent over the general average for that year. However, plan called for an increase of 19.8 percent. Cost of operation was lowered 4.3 percent against last year and against planned 2.7 percent even in face of the fact that February figures show an increase of cost over January. Individually, the oil industry was handicapped by poor productivity owing to low utilization of the time required, or set, for drilling and production. At some individual fields productivity fell from 46 percent in January to 43 percent in February, and 42 in March, with little improvement during April. At several of Baku fields loss of time in stoppages amounted to 24 percent in January and 27 percent in February. A close analysis of the causes invariably showed lack of organization to be the reason. Operations have improved in general during April over March but these improvements were too slight as to produce any appreciable effect.

Figures available for operations up to April 11th show the following plan fulfillment for the period as well as the portion of the plan for the year accomplished up to April 11.

	Plan Fulfillment	Portion of Plan for Year (Required 27.4 percent)
Electric Power	110.5	24.9
Coal production	97.2	23.4
Drilling	84.1	16.4
Oil and gas	93.4	21.8
Ore	100.3	24.5
Pig iron	95.5	23.5
Steel	106.3	23.4
Copper	111.3	19.4
Trucks	222.1	24.8
Combines	80.6	23.0
Locomotives	74.6	18.3
Freight cars	103.9	22.7
Machine tools	91.6	16.3

The Baku oilfields show an average plan fulfillment of 90 percent for the month of April, with 87.5 as low and 94 as high during individual days. Individually the Baku oilfield groups had operated as follows:

	Percent
Stalin group	98–100
Molotov	81– 95
Kergez	48– 74
Lenin	92– 95
Kirov	98–109
Asisbekov	74– 81
Artema	82– 90
Ordzonikidze	102–110
Keganovitch	77– 84
Aliati	57– 66

Grozni fields show an average of about 63 percent, with 60 as low and 72 as high. Of

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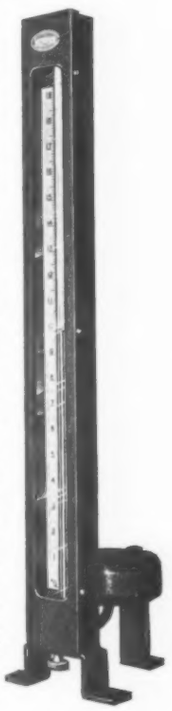

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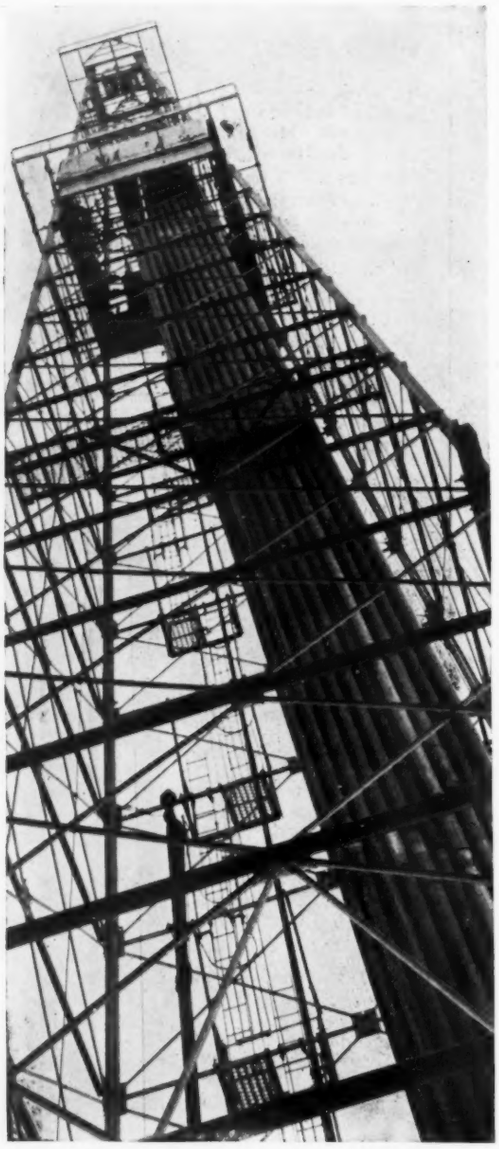

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these Molgabek operated between 75 and 90 percent, the October fields between 84 and 86, and Daghestan fields between 15 and 25 percent.

All other Soviet oilfields show following plan fulfillment:

	Percent
Maikop	71– 81
Bashkiria	55– 77
Emba	58– 63
Kalinin	81– 98
Voroshilov	25– 67
Sakhalin	90–100
Turcoman	62– 86

Thus except Stalin, Kirov, and Ordzonikidze groups of Baku, and Russian Sakhalin, no other Soviet oilfield has been able to live up to plan in crude production and drilling.

Official corrected figures for 1936 crude production were recently released and show following figures:

Official Production Figures

	Barrels		
	1934	1935	1936
Baku	133,000,000	136,432,000	143,947,300
Grozni	24,500,000	23,313,500	23,302,300
Maikop	6,500,000	8,335,500	7,741,100
Bashneft	150,000	2,841,000	6,773,900
Emba	1,575,000	1,708,000	3,262,000
Sakhalin	1,580,000	1,652,000	2,154,600
All others	2,473,700	2,404,900	4,513,900
Total	168,648,700	176,688,100	191,694,100

Corrected figures for Soviet operations for November and December, 1936, against WORLD PETROLEUM estimates, are:

	Crude Production	Run to Stills	Drilling
		Barrels	
November	16,019,300	14,797,300	583,311
December	16,412,900	14,058,800	631,819
Official total 1936	191,694,100	173,408,200	6,958,916
W. P. Estimate 1936	191,911,200	171,269,500	6,951,811

One of the recent developments at Baku has been the erection of a plant for production of yellow medicinal grade vaseline at Black Town.

A pipeline is to be constructed between Izberbash field of Daghestan and Makhatch Kala over a distance of 70 kilometers. At Makhatch Kala the crude carried over this new pipeline from Izberbash field will be transferred to the existing pipeline for further transportation to Grozni refineries. Two prospecting wells at Kala flow 3,500 bbl. and 2,100 bbl., respectively, of crude per day from a depth of 6,600 ft. and have enlarged the producing property by 90 hectares. At Molotov field three new wells were brought in flowing 3,500 bbl., 2,800 bbl. and 2,400 bbl., respectively, from the 8th horizon—increasing the producing area by over 60 hectares.

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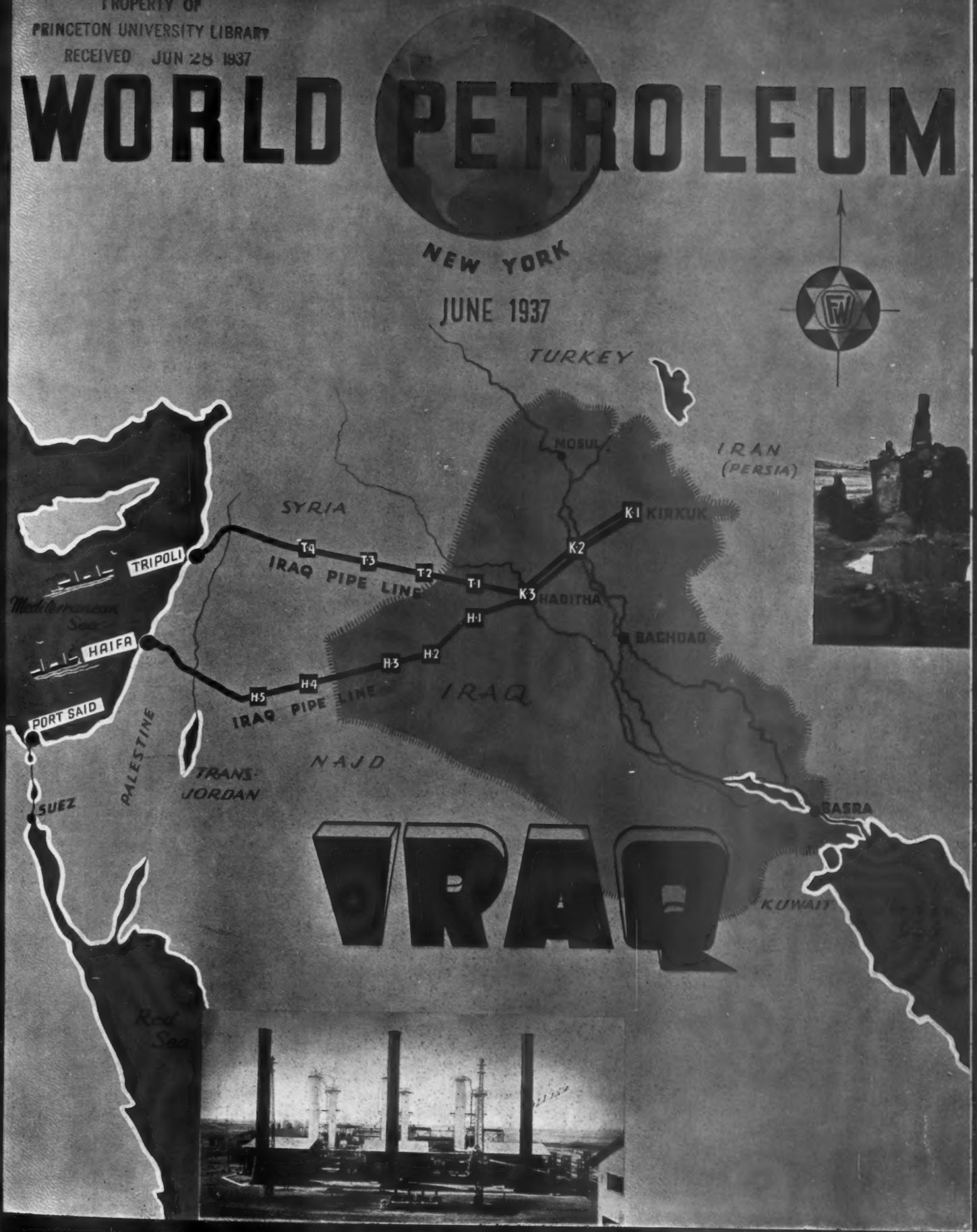

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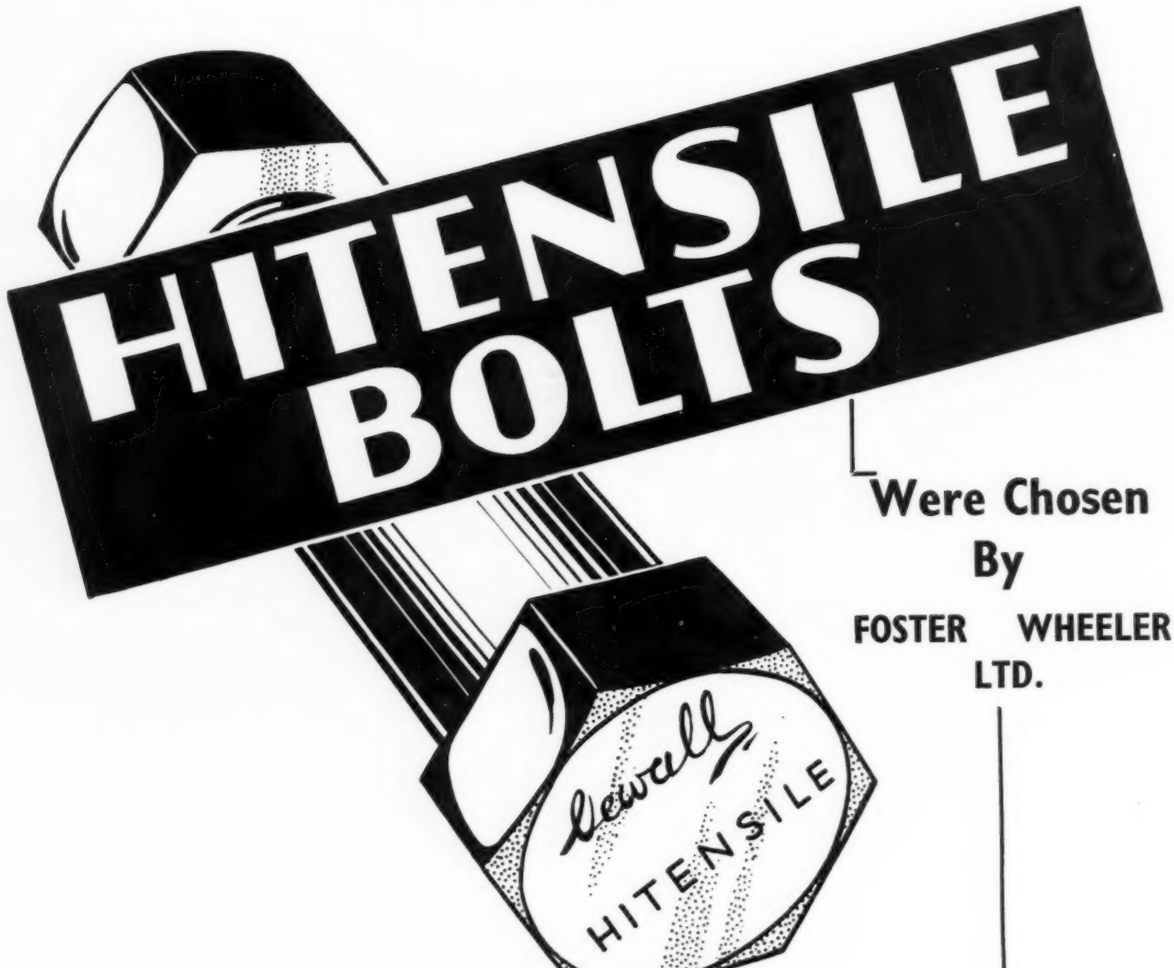

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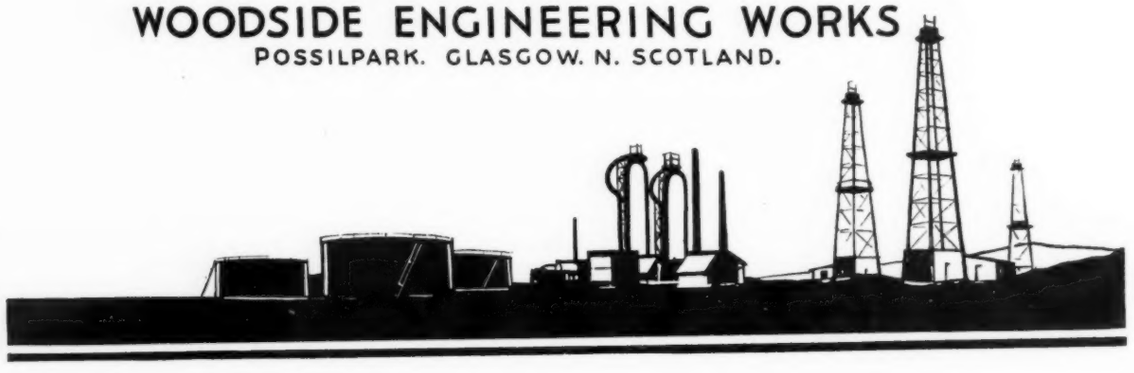

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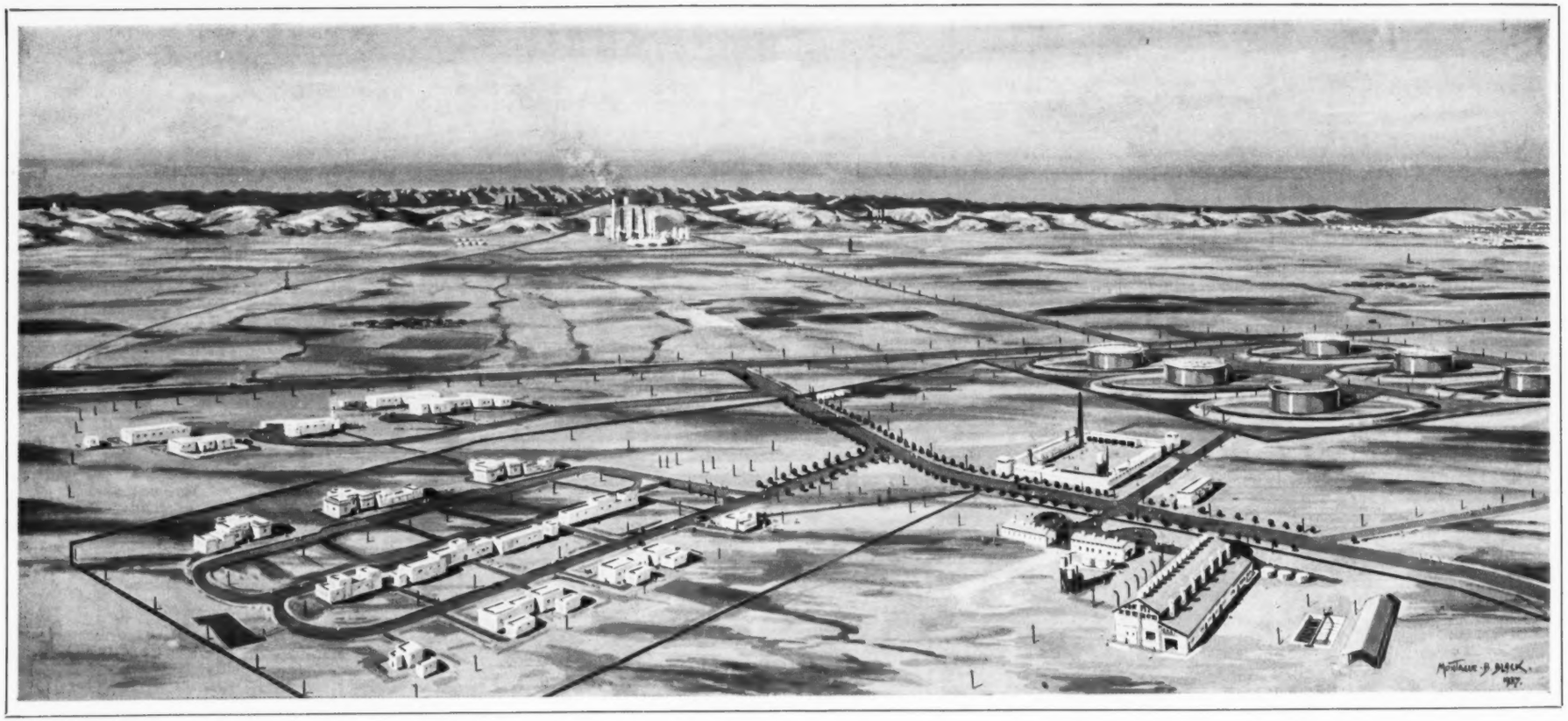

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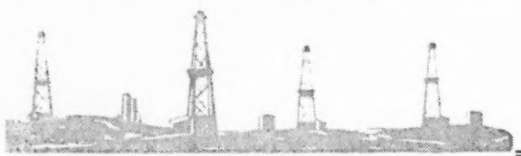
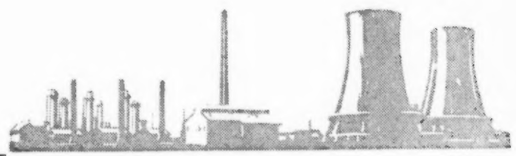




KIRKUK

PETROLEUM MAKES HISTORY IN IRAQ

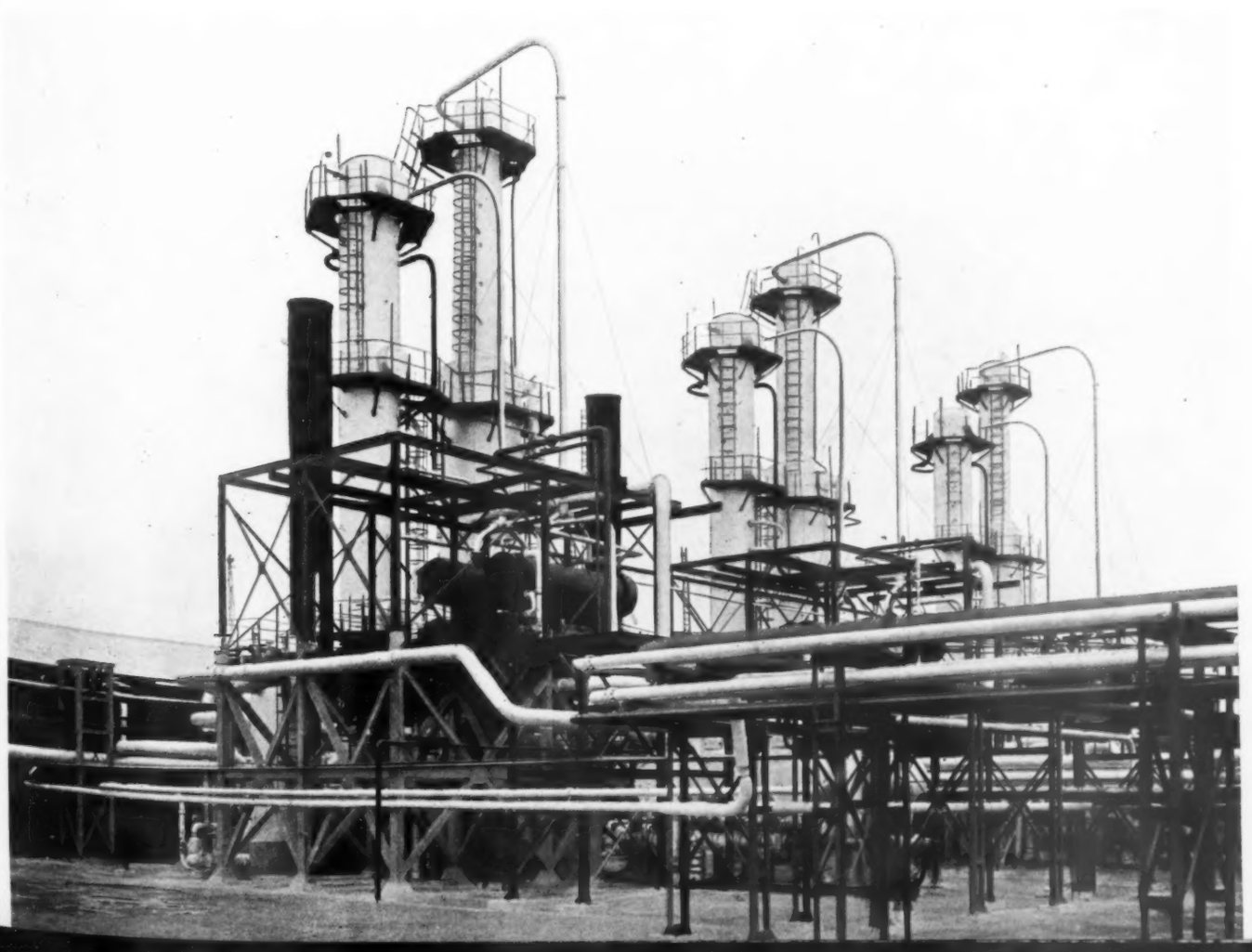
Foster Wheeler Plant Producing Crude Oil in Stabilised Form for Transport.

On the following pages is told the story of an engineering achievement which stabilises the entire production of crude from the great Iraq oilfield before it is pumped into the pipeline. Over 12,000 tons of oil are treated daily.

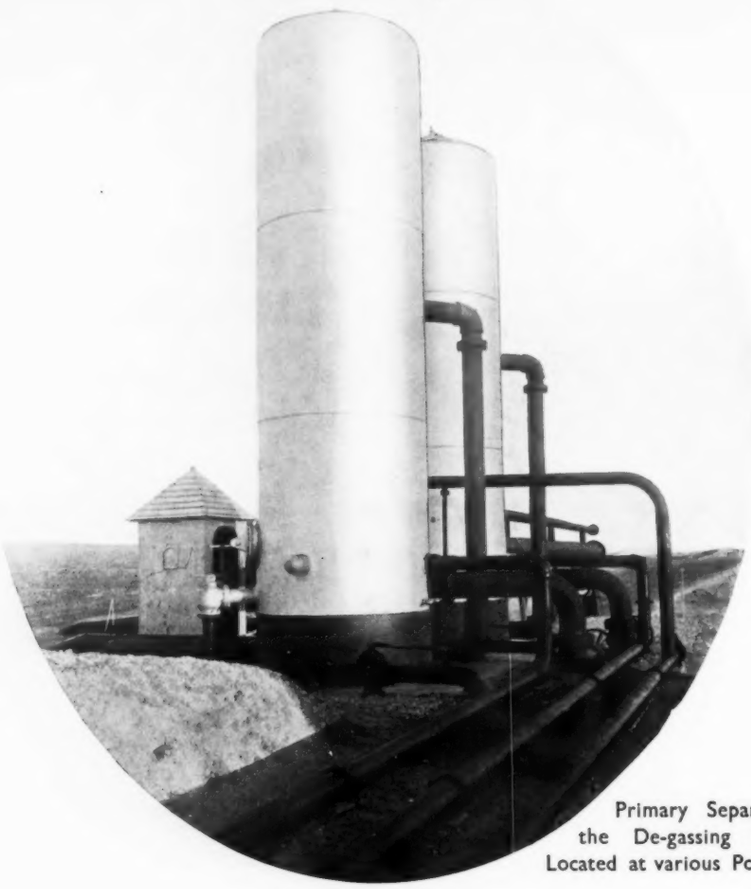
IN probably no other part of the world has petroleum been known and utilised by man for such a long time as in Iraq. There seems little doubt that the pitch which Noah used to make the Ark watertight was obtained from the bitumen springs existing at various places in the Tigris and Euphrates valleys. The basket boats used on these rivers by the local inhabitants were certainly coated with such bitumen, and archæologists have found many instances of its use for the damp-proofing of buildings long before the era of civilisation began in the west.

Not only was bitumen as such exploited by the natives, but oil from seepages was refined or tapped for local requirements. To-day can still be seen the remains of these ancient refineries, many centuries older than the industrial age, in which a primitive form of distillation was carried out.

That the exploration and development of the potential oil resources of the country was delayed until a comparatively recent period was due to conditions existing in the internal affairs of the region. For centuries the whole area had been devastated by warfare and invasions, and the rise and fall of



Kirkuk Stabilisation Plant.—First and Second Stage Columns with Condenser Structure of No. 3 Unit in the Foreground.



Primary Separators at One of the De-gassing Stations that are Located at various Points in the Oilfield.

successive dynasties left it far behind when industrial progress began to demand the natural treasure which lay hidden beneath its sandy wastes.

IMPORTANCE OF OIL TO IRAQ.

IN these early days oil was but an incident in the life of the Mesopotamian people, yet in the course of centuries it has come to be the most important factor in the affairs of the country.

Under the Treaty of Lausanne the Kingdom of Iraq was set up as a separate nation, the task of administrative organisation being carried out under the guidance of Great Britain acting under a mandate from the League of Nations. In 1929 Great Britain recommended to the League that Iraq should be given full independence, and this was made effective in 1932, when the country took its position among the family of sovereign states and was admitted to full membership of the League of Nations.

The modern history of the oilfields of Iraq dates back to 1901, when Iraq was a province of Turkey, and receiving little consideration from the administrative viewpoint. At that time William K

This Panoramic View Clearly shows Compact tion Plant.—Power-House and Cooling T

D'Arcy started negotiations for petroleum rights in upper Mesopotamia from the Turkish government. For the next twelve years there was an intermittent struggle between British and German interests, the balance of favour fluctuating from side to side. Thus, in 1904 the German interests obtained authority to carry out a survey and an option for further developments, but these led to no final agreement, while a change of government in 1908 put a stop to the negotiations which D'Arcy was on the point of concluding for a concession.

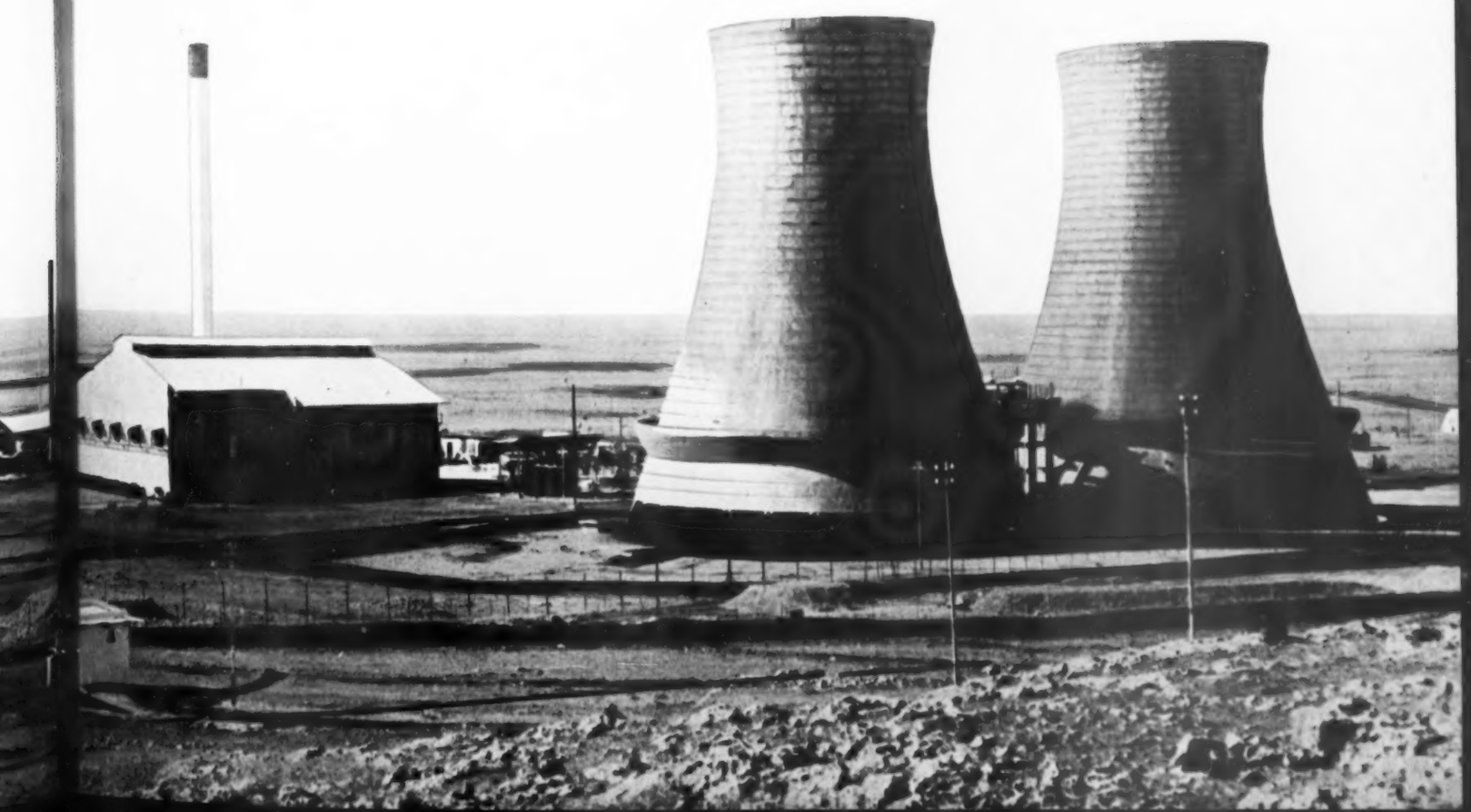
EFFECT OF COLLABORATION.

IN 1913 the previously competing interests entered a new phase, this time one of collaboration, with the formation of the African and Eastern Corporation, Ltd. In the following year the title of the company was changed to that of the Turkish Petroleum Company, Ltd. It united the interests of the National Bank of Turkey, the Anglo-Saxon Petroleum Company and the Deutsche Bank, and for the first time there was a union of British and German interests in the development of Mesopotamian oil.

This arrangement, however, made no provision for the D'Arcy interests, who

Iraq, the cradle of the world and rich in historical association, is—through oil—taking a prominent place in the modern economic world.

...mpact Arrangement of the Stabilisa-
...oling Towers in Right Foreground.



continued to assert their claims. The financial and diplomatic struggles of the two rivals continued until, in 1914, through the efforts of the British and German governments, the Turkish Petroleum Company was reconstituted. In the new organisation the Anglo-Persian Oil Company (now the Anglo-Iranian Oil Company)—that is, the D'Arcy group—took over the 50 per cent. interest formerly held by the National Bank of Turkey, the remaining shares being left equally divided between the Royal Dutch-Shell group and the Deutsche Bank.

The Turkish Petroleum Company, now with the active support of the British and German governments, resumed its efforts to obtain a concession and in June, 1914, succeeded in getting from the Turkish government a definite undertaking for the lease of the petroleum deposits of Mosul and Baghdad. Once again, however, progress was checked, for the outbreak of hostilities in Europe prevented the implementation of the undertaking. One result of the War was the sequestration of the Deutsche Bank shares in the company.

" OPEN DOOR " POLICY ENTERS SITUATION.

AFTER the War a new factor arose when France, having been given a mandate over Syria, claimed a voice in Near East affairs. By the San Remo agreement of 1920 it was agreed that France should have a 25 per cent. interest in any company acquiring petroleum rights in Iraq, but that such a company should be permanently under British control.

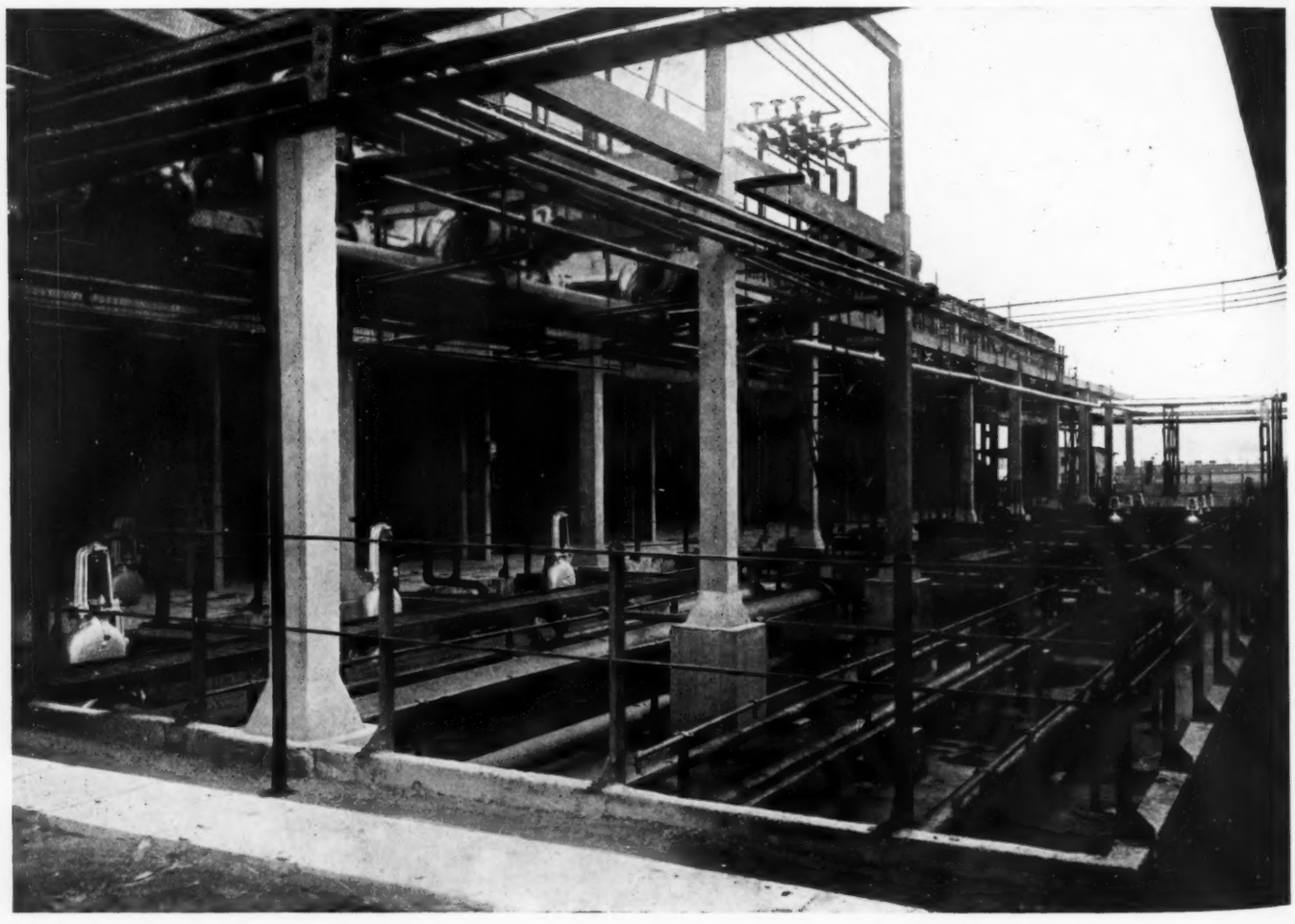
At this time the United States entered the field by raising the much-discussed issue of the " open door " policy. After considerable diplomatic negotiation, the American interests were included by the transfer to them of one-half of the shares originally held by the Anglo-Persian Oil Company.

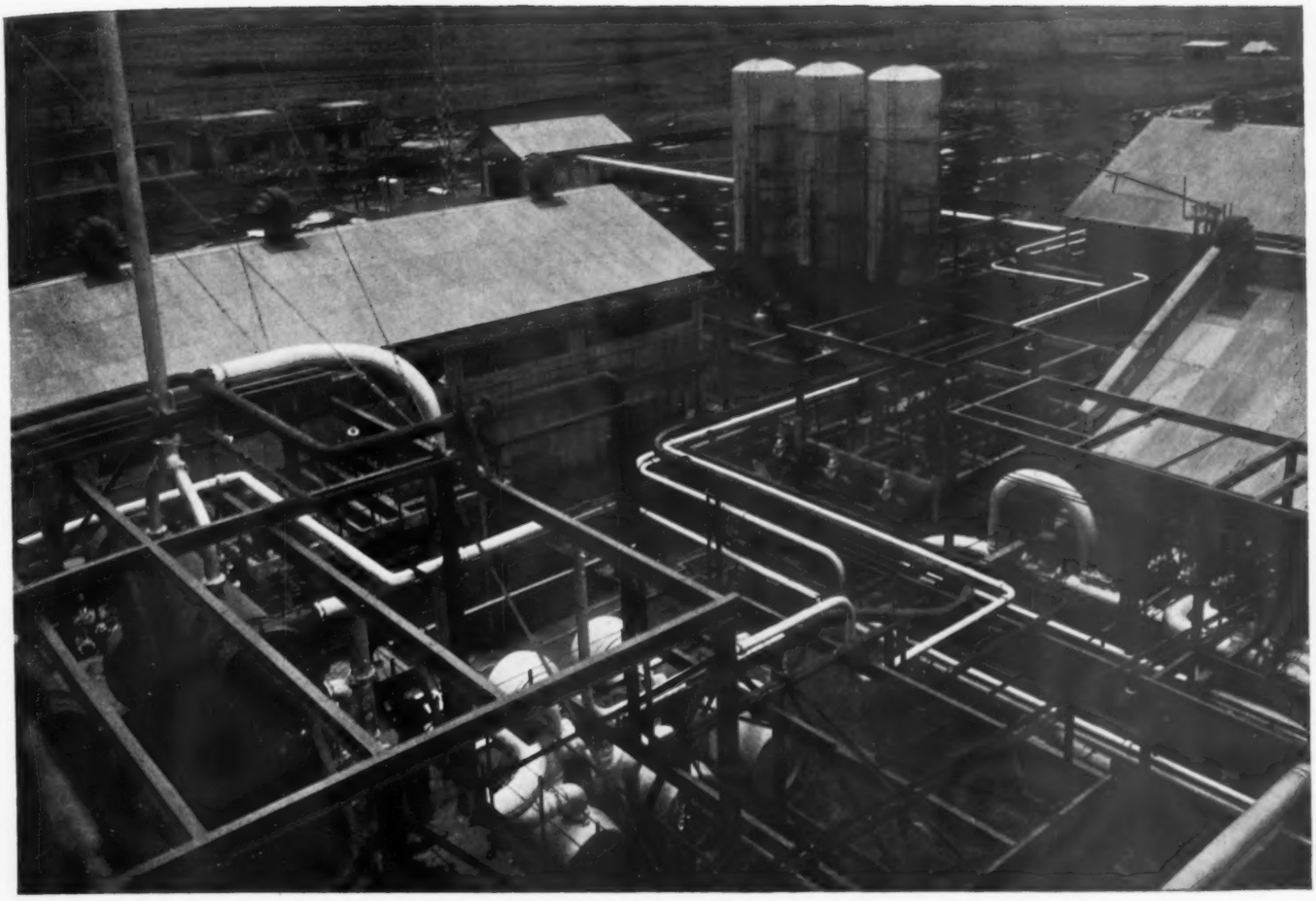
It was not until 1928 that the participation of the various interests was finally settled in the same proportions as they now stand. Apart from a five per cent. interest assigned to Participations and Investments, Ltd., representing C. S. Gulbenkian, the other 95 per cent. of the shares is equally divided between the following companies, each holding a 23¾ per cent. interest in the company: Anglo-Saxon Petroleum Company (Royal Dutch-Shell group), D'Arcy Exploration Company (Anglo-Iranian Oil Company), Compagnie Française des Petroles (French interests), and Near East Development Corporation (American interests).

SEVENTY-FIVE YEAR CONCESSION GRANTED.

IN the meantime, in 1925, negotiations with the Iraq government resulted in the Turkish Petroleum Company being granted a 75-year concession to exploit oil in Baghdad and Mosul. In 1929 the name of the company was altered to the more appropriate one of the Iraq Petroleum Company, and in the same year negotiations were opened for the revision of the original convention. These negotiations were continued at intervals, and were brought to a successful conclusion in March, 1931. Important modifications were made, one of

Cold-Oil Pump-House Manifold System, showing the " Mulsifyre Piping " for Protection against Fire.





Compressor House, Secondary Separators, and Cold and Hot Oil Pump-Houses. Neat Arrangement of the Piping is a Feature of the Entire Plant.

which was that the Company was now given the sole right to exploit oil over an area of 32,000 square miles to the east of the Tigris. The Company undertook to construct a pipeline system of a ***minimum*** capacity of 3,000,000 tons of oil a year, part of which was to run to a terminal in the Bay of Acre. If it so desired, the Company was free to build another pipeline to a terminal on the Mediterranean.

In the autumn of 1925 a geological party was sent to Iraq to survey the area covered by the concession, and twelve months later ten areas had been selected for testing by the drill.

FAMOUS DISCOVERY WELL.

So at long last, after many years of negotiation, drilling was commenced in April, 1927, and on October 14th of the same year the famous well at Baba Gurgur, near Kirkuk, came in with a production of 60,000 barrels a day. For a few days the well ran wild, a river of oil flowing into the nearby valley, but it was then brought under control and closed in pending further developments.

This initial success prompted further drilling, and operations in the Kirkuk area were rapidly extended. The results of this drilling confirmed the existence of oil of good quality, testing about 36 degrees Beaumé, and of very extensive potentialities in the Kirkuk structure. This structure extends north-west and south-east of the town of Kirkuk, and covers an area of over 50 square miles, being approximately 40 miles long and between one and two miles in width.

How vast are the reserves of oil in this area can best be judged by the fact that the production in 1936 was nearly 4,000,000 tons.

OTHER POTENTIAL AREAS.

OTHER areas in which the oil possibilities of Iraq have been investigated include the 46,000 square mile concession held by B.O.D. Company, Ltd., on the west bank of the Tigris, opposite to the area held by the Iraq Petroleum Company. The B.O.D. Company, which is controlled by Mosul Oil Fields, Ltd., obtained this concession in 1932, following the modification of the I.P.C. concession, and by the terms of its contract has eventually to construct a pipeline with a capacity of 1,000,000 tons a year, or to make satisfactory arrangements for the transport of a similar quantity. So far a number of wells have been drilled in the area, and oil has been struck flowing under its own pressure. At present the production is restricted to a few thousand tons per year, all of which is used internally, partly by the Company for its own operations and partly by the government for road-making purposes.

To the south, on the borders of Iraq and Iran, the Khanaquin Oil Company, which was formed in 1925 to acquire from the Anglo-Iranian Oil Company a concession in the Khanaquin area, has a producing field. This Company's production in 1936 amounted to 91,900 tons. The oil, which is refined at the 3,000-barrel daily capacity refinery at Alwand, was all used in Iraq.

Recent reports refer to the possibility of a new concession being granted for the exploration of the Basrah Liwa. It

At the Right is a Producing Well, a De-gassing Station in the Centre Background, while the Stabilisation Plant can be Seen in the Left Background.

is stated that this concession involves a loan of 2,000,000 dinars being made to the Government of Iraq, the loan to be paid off by deductions from royalties.

It is understood that the Iraq Government have been giving careful consideration to a project for the construction of a state refinery to meet the country's domestic oil requirements. Following a report by an expert, it is anticipated that work on this refinery will commence shortly.

THE GREAT I.P.C. PIPELINE.

THE possibilities of the Kirkuk area as a producer having been proved, it then became important that the construction of the pipeline should be put in hand without delay.

As planned, the lines were laid side by side from Kirkuk to Haditha, at which point they separate. One line continues to the west through Syria, Alaouite and Labanon to Tripoli on the Mediterranean, while the other branches away in a south-westerly direction across Trans-Jordania and Palestine to Haifa, in the Bay of Acre.

After a vast amount of preliminary survey work and organisation of transport and engineering requirements, the collecting together of material and supplies was started early in 1932, and in September pipe stringing was commenced from the three terminal points. Fourteen months later, on November 19th, 1933, the final connection of this 1,180-mile, 4,000,000-ton annual capacity pipeline was completed, establishing a through connection from Kirkuk to the shores of the Mediterranean. On July 14th, 1934, the first oil to travel through the line reached Tripoli for shipment to France. From that time until the end of 1936 about 8,000,000 tons of oil had passed through the lines.

Below : Water-Pumping Station on the Lesser Zab River. Old Steam Plant in Centre.

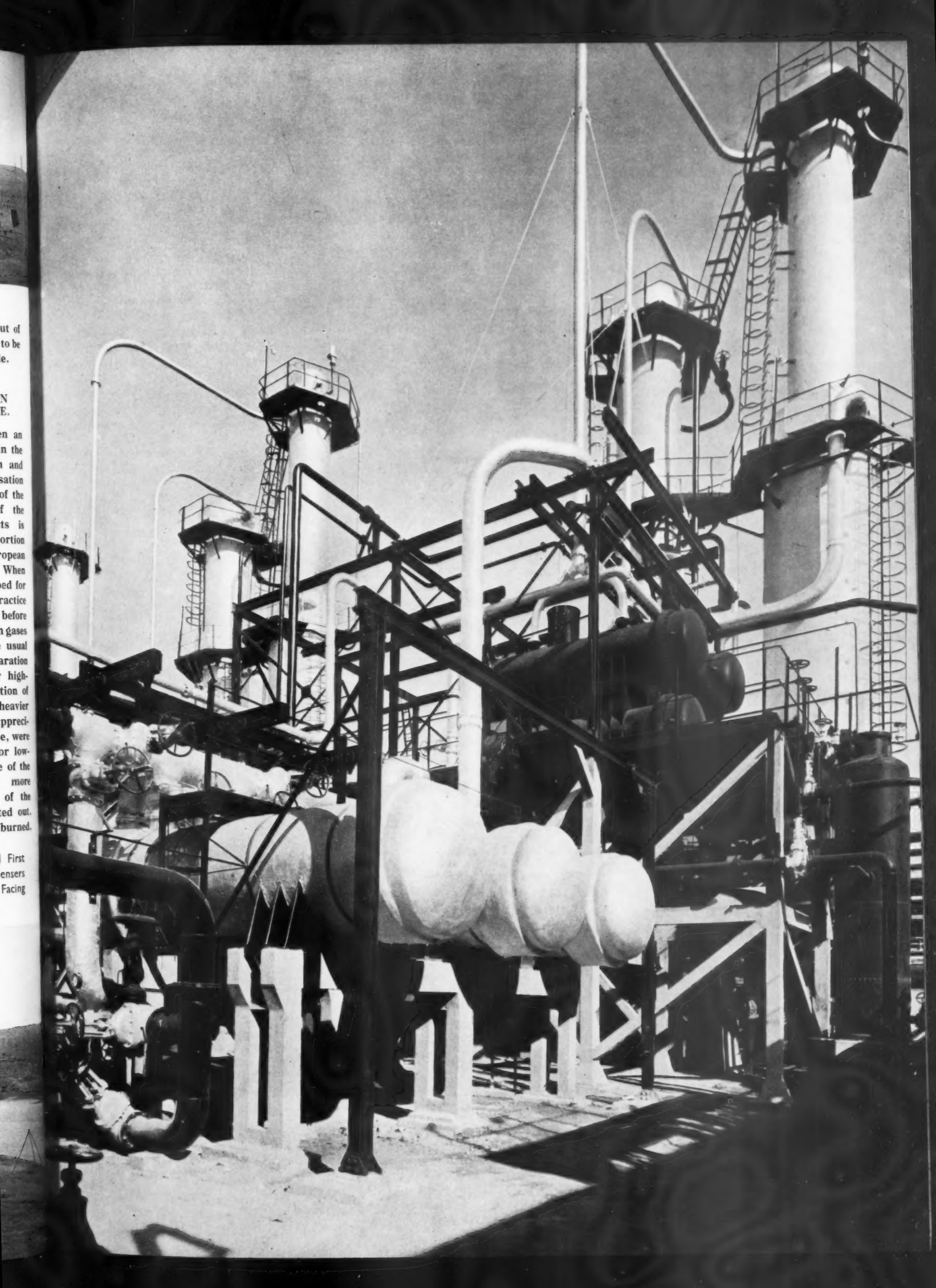
In the construction of this line, which cost nearly £10,000,000, over 200,000 tons of building material was used, and, in addition to railway transport, the Company's own motor haulage service moved material to the extent of nearly 25,000,000 ton miles. Many special problems in construction had to be overcome, in particular river crossings presenting difficulties in pipe laying and transport of material on account of great variations in water level. This problem was solved by the use of aerial cableways by which thousands of tons of materials and vehicles were safely carried across the Euphrates and the Tigris.

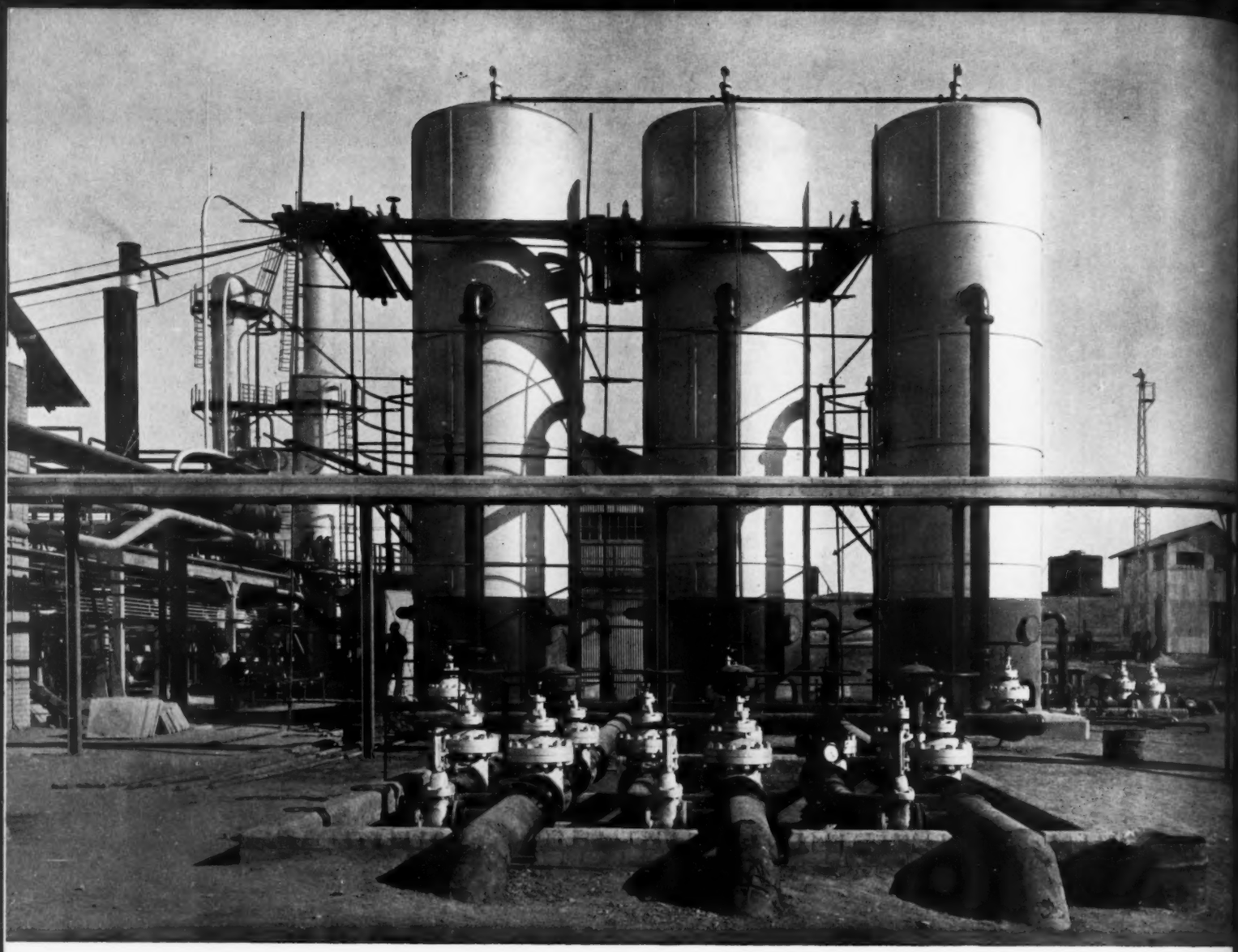
An important decision was that the line should be electrically welded throughout, and while this is in accord with modern practice, it is a testimonial to the skill of the welders that out of 177,000 joints only three were found to be faulty when the final test was made.

FOSTER WHEELER CRUDE OIL STABILISATION PLANT A UNIQUE FEATURE.

QUITE recently Iraq has seen an interesting and novel innovation in the petroleum world in the erection and completion of a crude oil stabilisation unit to handle the entire output of the field. As the requirements of the country for petroleum products is relatively small, the greater proportion of the crude is transported to European countries in its natural state. When the Kirkuk Field was first equipped for production commercially, the practice was to remove from the crude oil, before delivery to the tank farm, only such gases as could be separated off in the usual manner by mechanical separation in two stages. In the first, or high-pressure, stage the greater portion of the dry and some of the slightly heavier fugaceous gases, including an appreciable amount of hydrogen sulphide, were removed, while in the second, or low-pressure, separation again more of the unwanted gases, including more hydrogen sulphide and some of the useful gases, were also separated out. These gases were led off and burned.

First-Stage Heat Exchangers and First and Second Stage Vapour Condensers are Shown Prominently on the Facing Page.





Secondary Separators with Control Manifolds for Lines Leading from the Field De-gassing Stations.

In quality, the resultant crude oil was naturally sour and unstable.

Trouble arose soon in the refineries on account of noxious odours, and it became necessary to consider steps to overcome this nuisance. At first the problem was partly solved by placing caustic soda solution in the crude as the tankers were loaded at Haifa and Tripoli, but it was obvious that the more logical place to remove the hydrogen sulphide and stabilise the crude was at the field.

NEW PROBLEMS INVOLVED.

THE problems involved have been the result of a set of conditions which have called for a solution, in many cases, of a new or unusual character. The Iraq Petroleum Company has solved these difficulties by adopting the most logical measures to meet the problems, irrespective of standard accepted practice throughout the older petroleum fields. This does not imply a rejection of the experience which has been gained elsewhere—far from it. Constituted as it is, the Iraq Petroleum Company has available knowledge of the latest methods of oil production, transport and processing in the world's major oil-fields; but where conditions have warranted it, the Company has simplified the methods used elsewhere, and elaborated or modified them to meet unprecedented conditions.

The story of how Iraq crude oil has come to be stabilised and freed from sulphuretted hydrogen again, as in the case of the Iraq pipeline, illustrates the imagination and foresight with which the Iraq Petroleum Company has tackled these problems.

Long before oil first passed through the pipeline, it was realised that the nature of the crude oil would call for special measures in its handling. Dissolved in the crude oil under the conditions of production is a large volume of gas. This gas is entirely in solution at bottom hole and at well-head pressure, but the composition of the crude oil is such that, at reduced pressure, large volumes of gas are released. These gases contain not only such undesirable constituents as sulphuretted hydrogen, methane and ethane, but also propane, butane and higher hydrocarbons, which are desirable assets from the marketing point of view. No useful purpose could be served by the retention in the crude oil of the undesirable constituents. The sulphuretted hydrogen would give rise to corrosion in the pipeline, in the tankers, and in the refineries where the oil would be processed eventually. By eliminating the sulphuretted hydrogen, a valuable prolongation could be effected in the life of all equipment coming in contact with the crude oil, with a saving in the cost of refining and the elimination of atmospheric pollution.

BRITISH ENGINEERING FIRM GIVEN CONTRACT.

THE problem of determining how this could be best accomplished was placed in the hands of Foster Wheeler Ltd., London, who, in the short time of 15 months, designed, shipped and erected what is a unique plant in the petroleum refining world.

The only possible means of rejecting the undesirable constituents and of retaining the valuable hydrocarbons was obviously by efficient fractionation. Two limiting sets of conditions presented themselves :—

(1) The crude oil pressure could be let-down in atmospheric storage tanks, thus bringing about the release of vast volumes of gas containing not only the undesirable constituents, but also valuable hydrocarbons of the gasoline range. In order to recover the latter a large compression, absorption and stabilisation plant would be necessary, and would involve fractionation.

(2) A crude oil stabilising plant operating at well-head pressure and higher could take the complete crude oil with the gas in solution, and fractionate out, to a degree always under control, the undesirable constituents.

As is so frequently the case, an intermediate solution was found to be the most economical. By a partial reduction of the well-head pressure it was found that a considerable proportion of the sulphuretted hydrogen, methane and ethane could be purged without any appreciable amount of the heavier valuable constituents of the crude oil being carried away. To build a stabilising unit of such capacity that it would handle these gases when they could be got rid of by a simple, inexpensive method of pressure reduction and venting would obviously be uneconomic. At the same time, it was apparent that the well-head energy in the crude oil should be conserved as far as possible. After considerable investigation, the optimum economic relationship between the let-down system and the stabilising plant was found.

Driving Motors for the Cold-Oil Pumps.
Switch Gear on the Left.

A Water Pump at the Lesser Zab Station.

WHAT THE LET-DOWN SYSTEM INVOLVES.

As eventually adopted, the production and let-down system is as follows :—

The crude is not let down to atmospheric pressure, but is delivered to the stabilisation plant under part of the original well pressure. Between the wells and the plant are two stages of gas/oil separation. The first, referred to below as primary, is situated at a convenient point for the group of wells which feeds it, and the second, referred to below as remote separation, is placed at a point near the stabilisation plant. After passing through the primary separators, which temporarily are hand-controlled at required pressure on the gas outlet, the oil flows to the remote or secondary separators through a line so designed and controlled that the pressure in it never falls below the pressure in the primary separators. This pressure constitutes, in fact, the vapour pressure of the oil in the line.

The secondary separators are fitted with automatic gas pressure regulators, as well as float control valves on the common oil outlet line. This line functions as charging ring for the charging pumps to the process plant. The gas from the secondary separators is led off to the process plant for fuel purposes.

FURTHER DESIGN CONSIDERATIONS.

In determining the precise duty for which the stabilising plant should be designed, the requirements of the various refineries to which the crude oil would be distributed had to be considered. There now exists in certain countries a market for the liquefied gases, propane and butane, the demand for the latter being considerably in excess of that for propane. It was therefore considered expedient to retain in the stabilised crude oil proportions of each of these two components, generally in the ratio of the probable market requirements. These quantities were, of course, dictated to some extent by the necessity of producing a stabilised crude oil which would not suffer any further weathering or loss of valuable constituents by gassing during the long transport from the fields to the refiner.

The stabilising plant was therefore designed for the production of a stabilised crude of approximately constant composition. This was in itself no easy problem, as the composition of the crude oil leaving the let-down tanks varies continuously from day to night and from summer to winter. In addition, the cooling water required has to be pumped a distance of some 18 miles from the Lesser Zab river, and, in view of the enormous quantities otherwise involved, economics required the installation of water-cooling towers. The varying performance of these towers under changing climatic conditions introduced a further complicating factor into the design.

It was realised that the inclusion of the stabilising plant in the system between the fields and the pipe line termini must not jeopardise the full continuous pumping capacity of the pipe line. Furthermore, once the system had been flushed out with stabilised crude, no unstabilised oil should be allowed to enter it since, owing to its huge capacity, further cleaning out would be a lengthy process.

Detailed Description of the Kirkuk Stabilisation Plant.

With Notes on Some of the Principal Equipment Installed

THE plant was designed as three units, any two of which would be capable of handling the complete throughput of the pipe line and one of which would be continuously available as a standby. As a further precaution all corresponding equipment on each of these three units was interconnected in such a way that each item would be capable of immediate substitution by a corresponding item. Thus the first-stage column on No. 1 unit is capable of being used with the remainder of the equipment on either units 2 or 3. Similarly the first stage column on unit No. 3 is capable of being used with the remainder of the equipment on either units 1 or 2, and so on.

Each crude oil stabilising unit has the capacity to handle under normal operating conditions 40,000 barrels per day of unstabilised crude oil, and to produce therefrom a stabilised crude by the elimination of the sulphuretted hydrogen, methane, ethane, practically all of the propane and a proportion of the butane.

METHOD OF OPERATION.

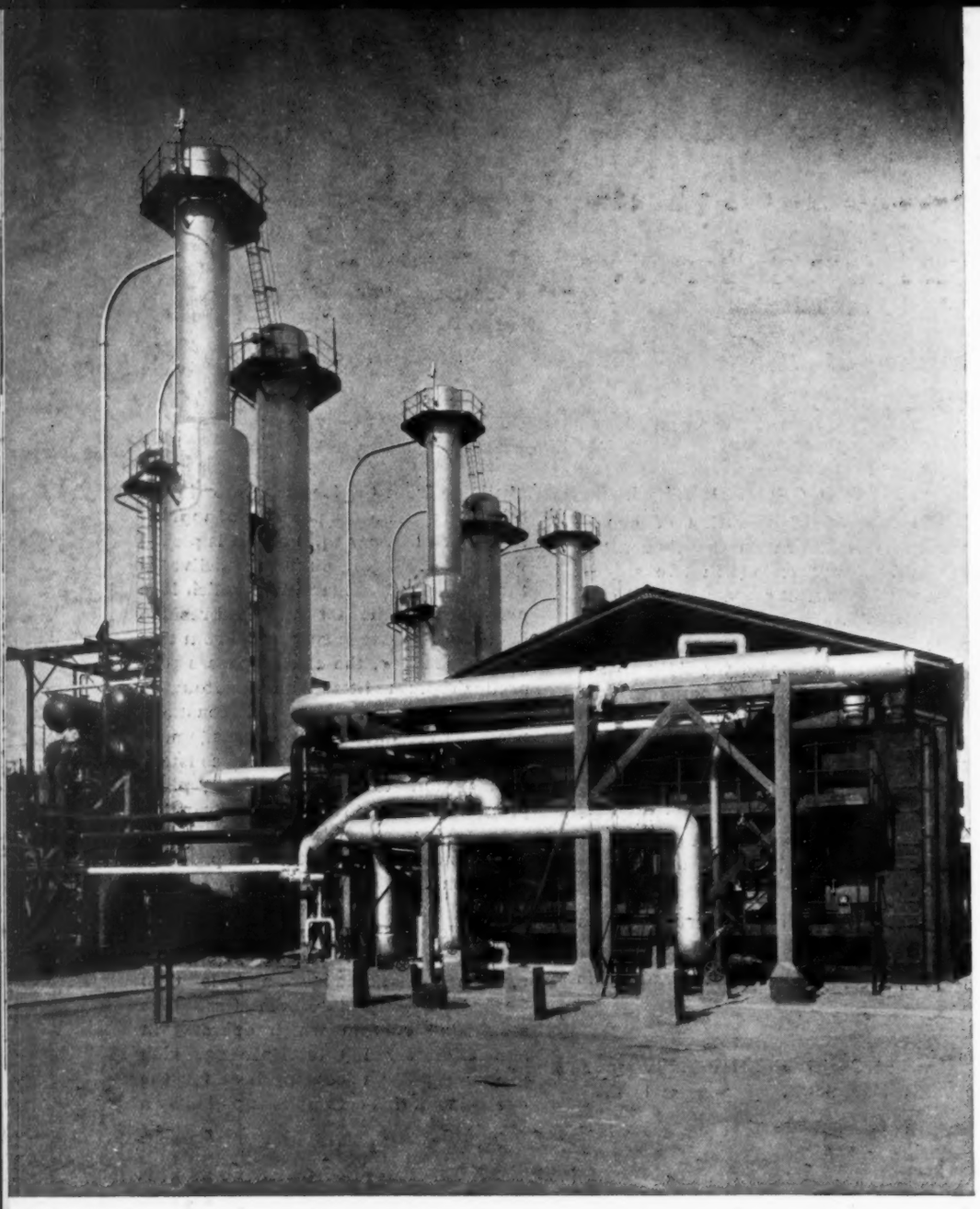
The method of operation of one of the units is shown on the flow chart. It involves processing in two stages. Essentially the first stage secures the elimination of the undesirable constituents, effects a light topping of the crude and the partial fractionation of the light distillates ; the second stage fractionates the light distillate and the vent gas from the first stage, and finally the topped crude from the first stage is blended with the stabilised light distillate to produce the stabilised crude. The undesirable constituents in gaseous form are used as fuel and the excess led away to a burning point.

In greater detail the operation is as follows :—

The supply of unstabilised crude oil is available from the last separator in the let-down system at a pressure of approximately 50 lbs. per sq. inch. It is picked up by the charging pump and delivered through a heat exchanger in which it is preheated by the hot stabilised residue from the first-stage column. From this heat exchanger, the charge passes to a preflash column fitted with an automatic temperature controller and constant-pressure regulator. This arrangement ensures a charge of essentially constant composition to the stabilising plant proper by taking the crude oil of varying composition and subjecting it to venting under constant temperature and pressure conditions.

After leaving this column the charge is further heated in another first-stage residue heat-exchanger and is then flashed directly into the first-stage stabilising column which operates at approximately 100 lbs. per sq. inch pressure. The necessary heat for the operation of this column is supplied by a

Residual Coolers and Heat Exchangers, with the Cold-Oil Pump-House in the Background.



Above at the Right is the Tube-Still for Unit 1, showing Firing and Inspection Platforms.

tube-still serving as a circulation heater through which a portion of the residue leaving the base of the column is pumped —the return line from the tube still entering the column at a point below the bottom tray.

Stabilised residue from the base of this first-stage column flows through the tubes of the second column reboiler in which the necessary heat is abstracted for the operation of the second column. From the heating system of the second column reboiler the partially-cooled residue flows through the heat exchanger in which the charging stock is preheated and thence through a cooler to an orifice mixer in which it is blended with the stabilised residue from the second column. The light vapours and non-stabilised gases from the top of the first-stage column flow to a vapour condenser, and thence to a reflux accumulator from which the necessary amount of condensate is pumped back to the top of the column to serve as reflux.

Uncondensed vapours and non-condensable gases from the first-stage reflux accumulator pass to the motor-driven compressors and thence to the second-stage stabilising column which operates at a pressure of approximately 400 lbs. per sq. inch. Such condensate from the first-stage reflux accumulator, as is not required as reflux, flows to a surge tank from which it is picked up by a distillate pump. This pump delivers it through a heat exchanger in which it is preheated by the hot stabilised residue from the second-stage reboiler. The preheated condensate stream is then flashed directly into the second stage stabilising column.

The vapours from the top of the second-stage column flow to a vapour condenser from which the condensate and non-condensable gases pass to a reflux accumulator. The condensate is pumped back as liquid reflux to the top of the second-stage stabilising column and the non-condensable gases are vented from the system through a pressure relief-valve set to maintain the requisite pressure on the second stage of the unit. The bottoms from the second-stage column flow under pressure to the second-stage reboiler, the latter being heated by means of the first-stage residue. Vapours from the reboiler are vented back to the base of the second-stage column. From the reboiler the stabilised residue flows to the condensate heat exchanger and thence through a cooler to the orifice-mixer for final blending back with the first-stage residue.

Stabilised crude oil thus produced flows under plant pressure to the first pumping station on the trans-desert pipeline. It is interesting to note that the stabilising of the crude oil is carried out in the absence of water or steam, thus avoiding the corrosion of the plant by sulphuretted hydrogen.

In June, 1935, it was decided to put the project into execution. The contract for the design, supply, and initial operation of the crude-oil stabilising plant proper was placed with Foster Wheeler Ltd., London, who had supplied the original Kirkuk topping plant. The water-cooling tower contract was awarded to J. C. Gammon Ltd., of Bombay, and the Iraq Petroleum Co. set about the preparation of the necessary foundations and the laying of an 18-mile long supply line for water from the Lesser Zab river. Kirkuk—the natural centre for the concentration of the delivery lines from the various wells throughout the Kirkuk field—was chosen as the site for the plant.

The following are details regarding the crude-oil stabilising plant equipment, power and boiler station, cooling towers, &c.

continued on page 27

TOWERS, HEAT EXCHANGERS HIGH PRESSURE VESSELS

Part of the Kirkuk Stabilisation Plant.

AND OTHER EQUIPMENT

FOR the Kirkuk stabilisation plant, we supplied to the order of Foster Wheeler Ltd., pressure tanks and structural steel work. Our well-equipped engineering works at St. Helens, Lancs, are in a position to manufacture and supply all types of oil-refining equipment for erection in any part of the world.

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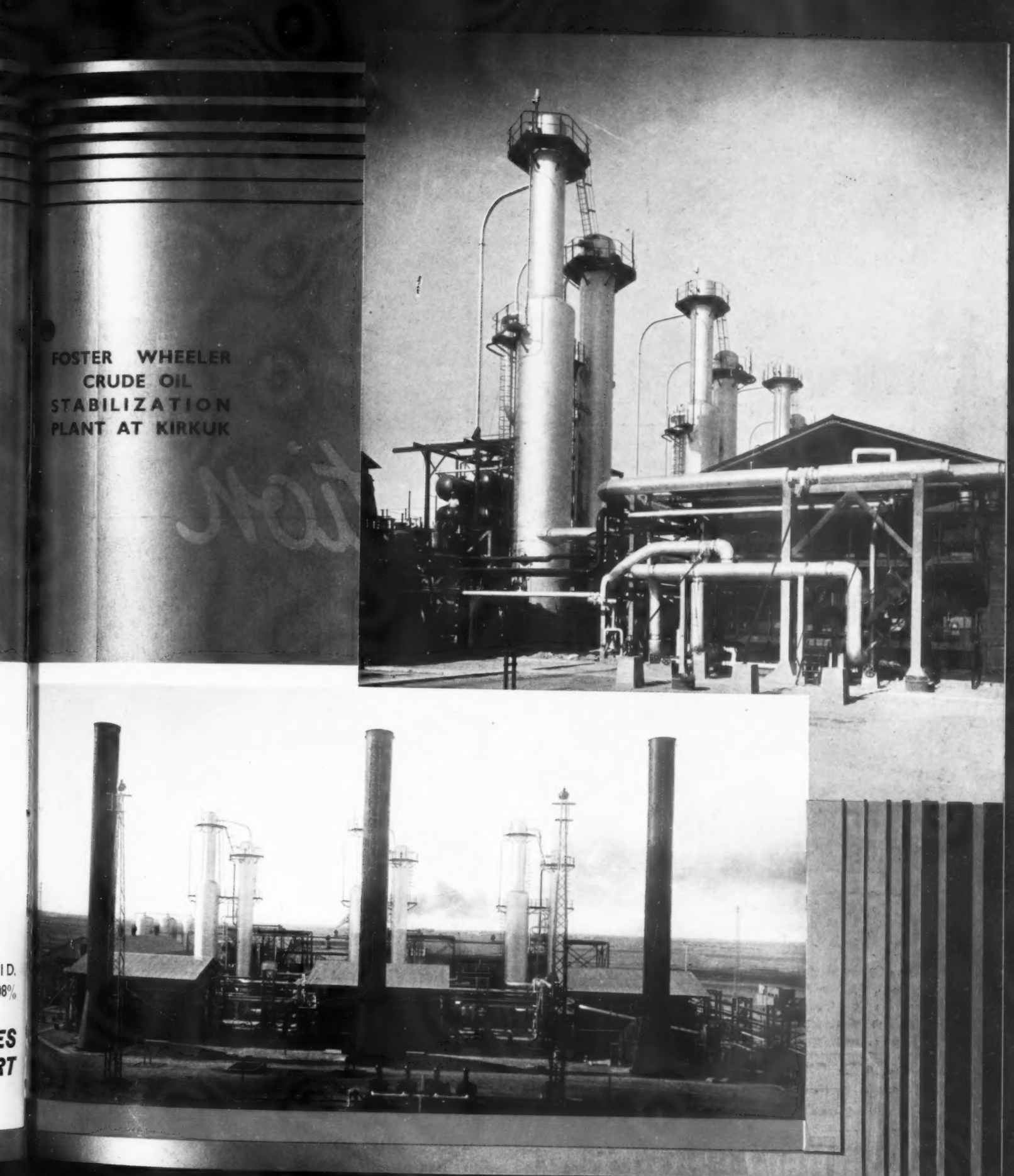


FOSTER WHEELER
CRUDE OIL
STABILIZATION
PLANT AT KIRKUK

WHEELER
LIMITED

Aldwych House, London W.C.2

Associated Companies
S.A. FOSTER WHEELER
FRANCE
FOSTER WHEELER Ltd
CANADA

Oil Fire Hazard
eliminated by the "MULSIFYRE" SYSTEM

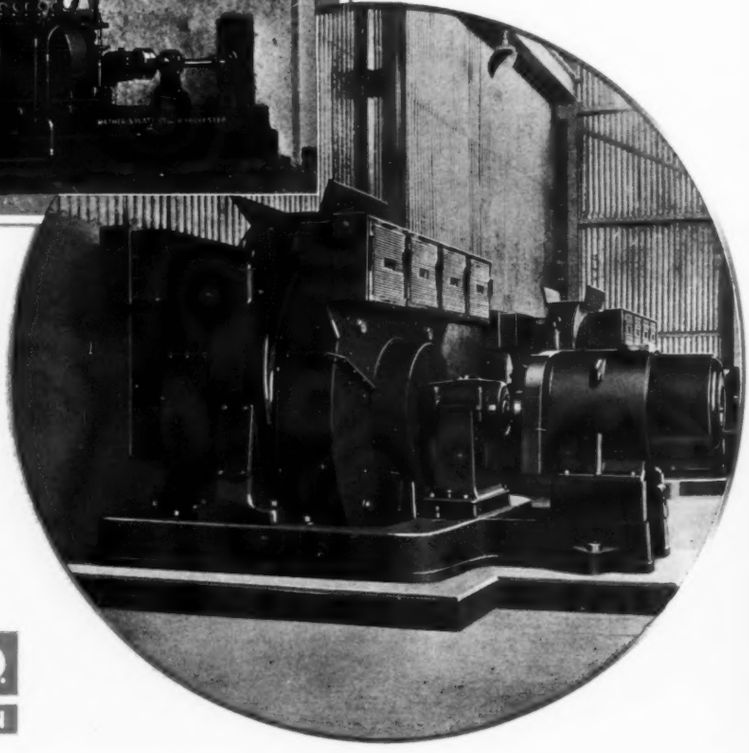
With the " Mulsifyre " System, burning oil is converted, by the use of WATER only, into a non-inflammable emulsion.

The photograph reproduced alongside shows a typical oil fire, staged for demonstration purposes, which is extinguished by " Mulsifyre " equipment within three seconds.

That below shows the cold-oil Pump House at Kirkuk with " Mulsifyre " equipment visible near the ceiling.

Pumps

Mather & Platt Pumps enjoy a unique reputation for efficient and reliable service in every branch of the oil industry. Those illustrated alongside are of the low gravity distillate type. They are driven by Mather & Platt Squirrel Cage Induction Motors situated on the far side of the fire wall.



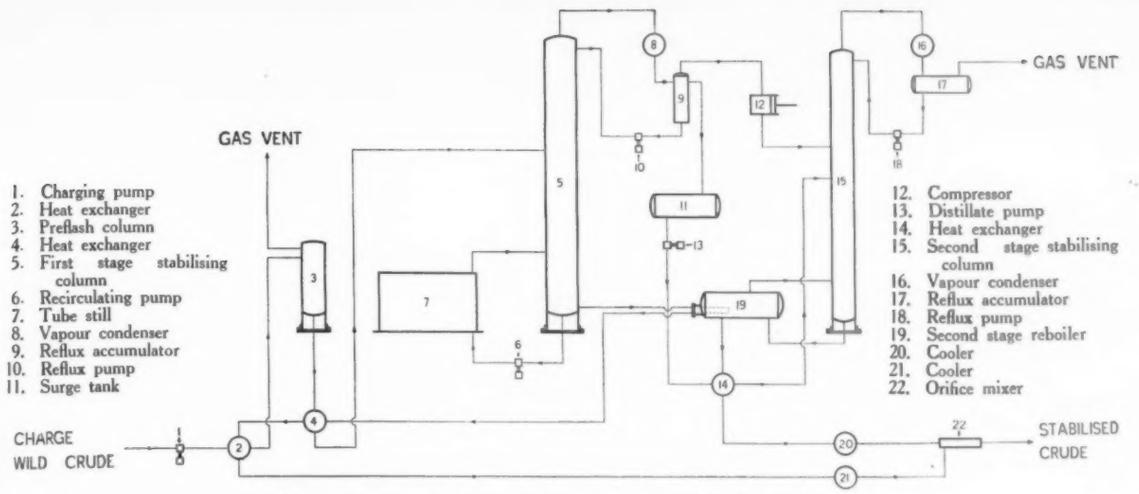
Motors

In addition to the motors driving the Pumps illustrated above, Mather & Platt Motors are performing many duties at Kirkuk, and the machine shown alongside is one of several 225 B.H.P. Salient Pole Synchronous type Motors driving Compressors.

The electrically-driven Pumps illustrated were supplied through Messrs. Foster Wheeler Limited.

MATHER & PLATT LTD.

MANCHESTER & LONDON



Flow Chart of the Foster Wheeler Crude Oil Stabilising Unit.

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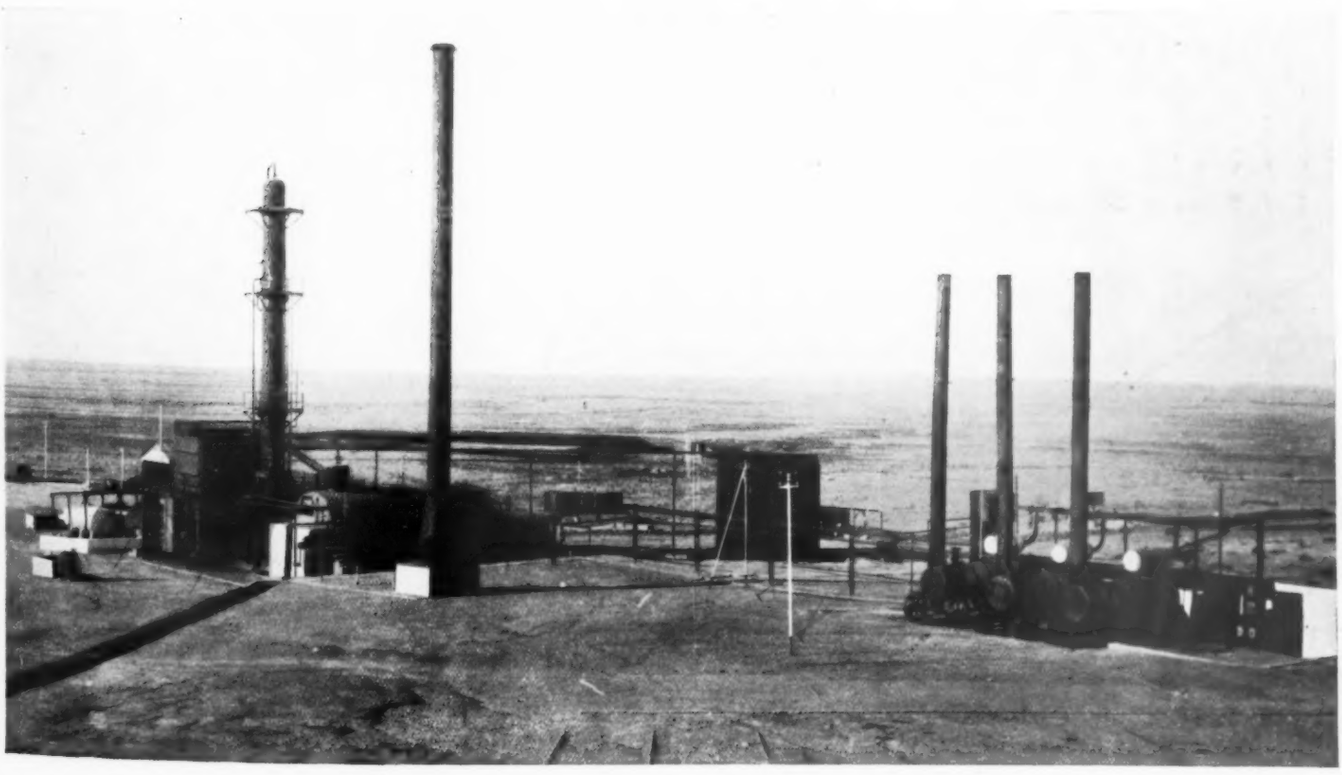
CRUDE OIL STABILISING PLANT EQUIPMENT. TUBE-STILLS.

THESE are of the latest Foster Wheeler double-end-fired all-radiant type having the heating surface located in a single row in the roof, on the floor and on the two side walls of the heater. The heat liberation in each tube still is approximately 120 million B.Th.U. per hour. The heating surface consists of 6-in. o.d. bare seamless steel tubes each 30 ft. effective length.

The roofs of these tube stills are of the Detrick suspended flat-arch type, and the settings are of similar Detrick construction arranged for air cooling, and finished off on the outside with Transite sheeting. These tube stills, being of the all-radiant type, operate at temperatures somewhat higher than the conventional radiation and convection type of tube still, and special care is necessary in their design to ensure their standing-up well to the operating conditions.

The horizontal hanger bars used for the furnace roofs have an inverted T-shape section on which the tiles are assembled. Support for these hanger bars is provided by an overhead steel structure from which the bars are freely suspended. For the wall structures a vertical hanger bar is used which has a " T " shape section for anchoring the tile, and also at the lower end a shelf for taking the weight of the unit section of the tile which it supports. The hanger bars are completely outside the tiles, and are designed to radiate heat at a rate such as to prevent destructive overheating.

In order to provide free suspension, bolting of the horizontal roof hanger bars to the supporting steel framing is



Original Foster Wheeler Topping-Plant at Kirkuk, which Proved Invaluable during the Pipeline Construction Period. It was Erected about Seven Years ago.

avoided as far as possible, thus permitting free expansion movement in all parts of the refractory structure exposed to the furnace heat.

For the furnace walls short vertical groups of tiles are sectionalised. This is done to eliminate wall loading on the tile and prevent crushing of the refractories under actual furnace heat.

Peabody combination gas and oil burners are employed for firing the tube stills.

The three stacks, one serving each tube still, are of the self-supporting type, fabricated of mild steel and lined with special high grade firebrick. Each stack is approximately 90 ft. high. The stacks are connected to the tube stills by underground brick flues.

PREFLASH COLUMNS.

THE Foster Wheeler preflash columns are 5 ft. 9 in. diameter by approximately 20 ft. high designed for a working pressure of approximately 150 lbs. per sq. inch.

FIRST-STAGE STABILISING COLUMNS.

THESE are each about 70 ft. high and have a diameter of 4 ft. 6 in. in the upper section and 8 ft. in the lower section. They are designed for an operating pressure of 100 lbs. per sq. inch. These and the preflash columns were supplied by Edwin Danks (Oldbury), Ltd.

SECOND-STAGE STABILISING COLUMNS.

THESE are 5 ft. 3 in. diameter by approximately 68 ft. high, and are designed for an operating pressure of 400 lbs. per sq. inch. The shell thickness is $1\frac{3}{8}$ in. These columns have been fabricated by Class I fusion welding. Before leaving the workshops where they were fabricated, the shells were wholly annealed and all welds X-rayed. Having in mind the international character of the Iraq Petroleum Co. it is interesting to note that under subcontract from Foster Wheeler Ltd., London, one was built by Foster Wheeler Corporation, New York, and the other two by the Babcock & Wilcox organisation—one in Renfrew, Scotland, and the other in France.

These columns are products of the very latest practice in engineering work of this type and represent a considerable achievement by the manufacturers concerned. Their very size created numerous difficulties in transport, especially in regions where handling facilities for such heavy, bulky material are limited.

HEAT EXCHANGERS, CONDENSERS AND COOLERS.

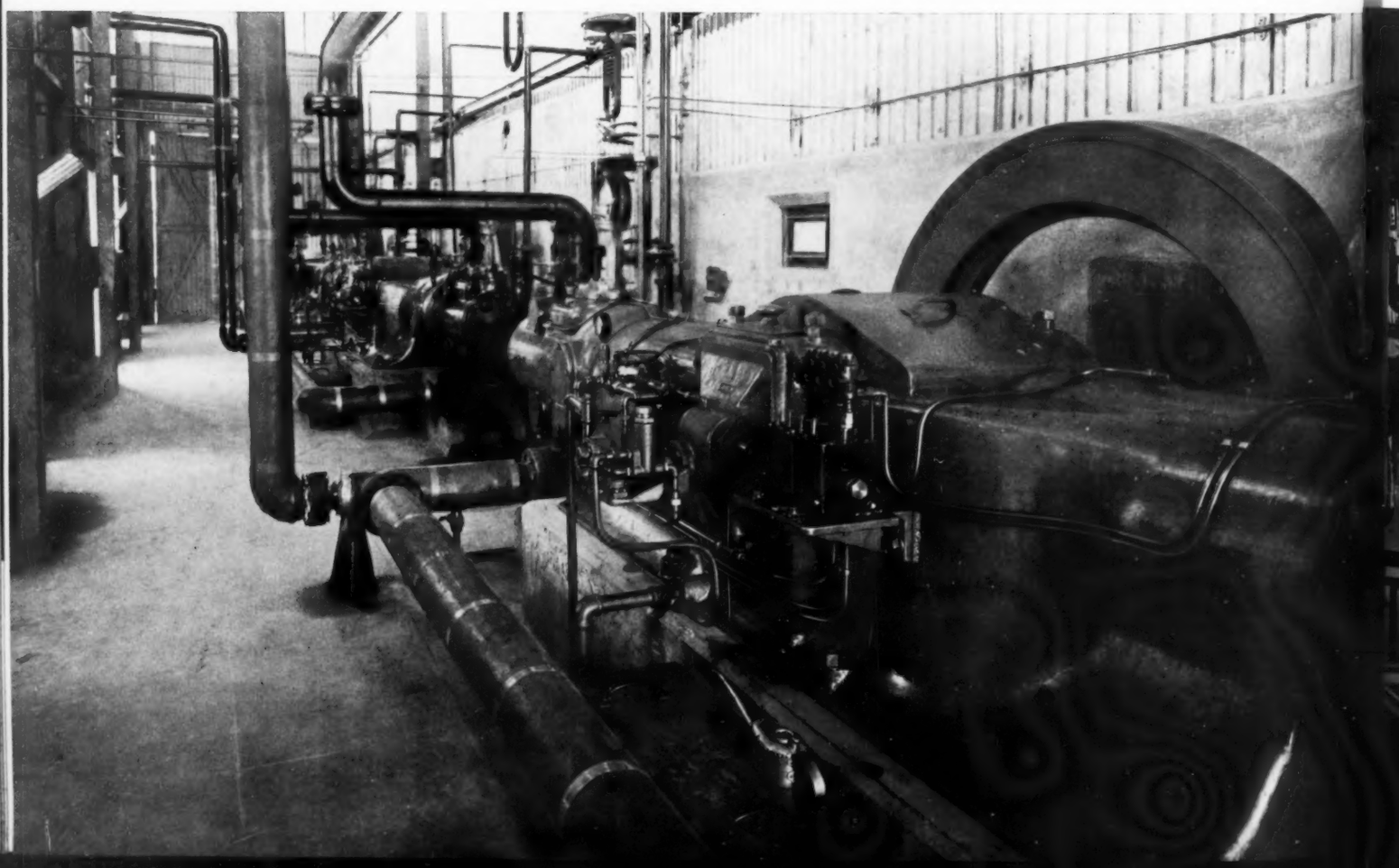
THESE are all of the Foster Wheeler shell-and-tube floating-head type with removable tube bundles. Approximately 60,000 sq. ft. of surface is incorporated in these units, necessitating the use of about 43 miles of 1-in. diameter tubing. All tubing is standardised in 14 ft. lengths to reduce to a minimum the necessity for carrying spare tubes or tube bundles. All condensers and coolers are tubed in Admiralty metal and all heat exchangers in steel. The diameters of the shells vary from 42 in. to 10 in., three sizes only being employed. The larger units were fabricated by Richardsons, Westgarth, of West Hartlepool.

REBOILERS.

THE second-stage reboilers are of the tank type suitably baffled and fitted with heating surface in the form af a removable tube bundle with floating head.

COMPRESSORS.

THE compressors are of the balanced, opposed type having horizontal twin cylinders. This type has been developed as the result of experience in gasoline stabilisation in the U.S.A. whence they were supplied. The drive is by means of Mather & Platt salient pole synchronous type motors running at 250 r.p.m. Each motor is capable of developing 225 b.h.p. and is designed to operate on a



Two-Cylinder, Double-Acting, Opposed-Piston Type Compressors are Installed.

3,300 volts, 50 cycles, 3-phase supply. The compressor motors are used to correct the power factor of the complete stabilisation plant system, being designed to operate with a 0.9 leading power factor.

The motors are designed for auto-transformer starting with a starting current not exceeding twice the full load current. They are direct coupled to the compressors through flexible pin couplings and the drive is carried through a 9-in. fire wall so that all the electrical gear is isolated from the compressor house itself.

PUMPS.

ALL the pumps on the process plant are of Mather & Platt's manufacture and are of their " Plurovane " multi-stage construction. They run at speeds of approximately 975 and 1,450 r.p.m., and are driven, through wall boxes in a fireproof partition wall, by Mather & Platt screen-protected squirrel-cage, rotor-induction type electric motors designed to operate on a 380 volt, 50 cycles, 3-phase supply.

The main process pumps are fifteen in number, there being three pumps for each of the five individual duties involved. Each set of three pumps is arranged in such a manner that any one pump may be used on any unit.

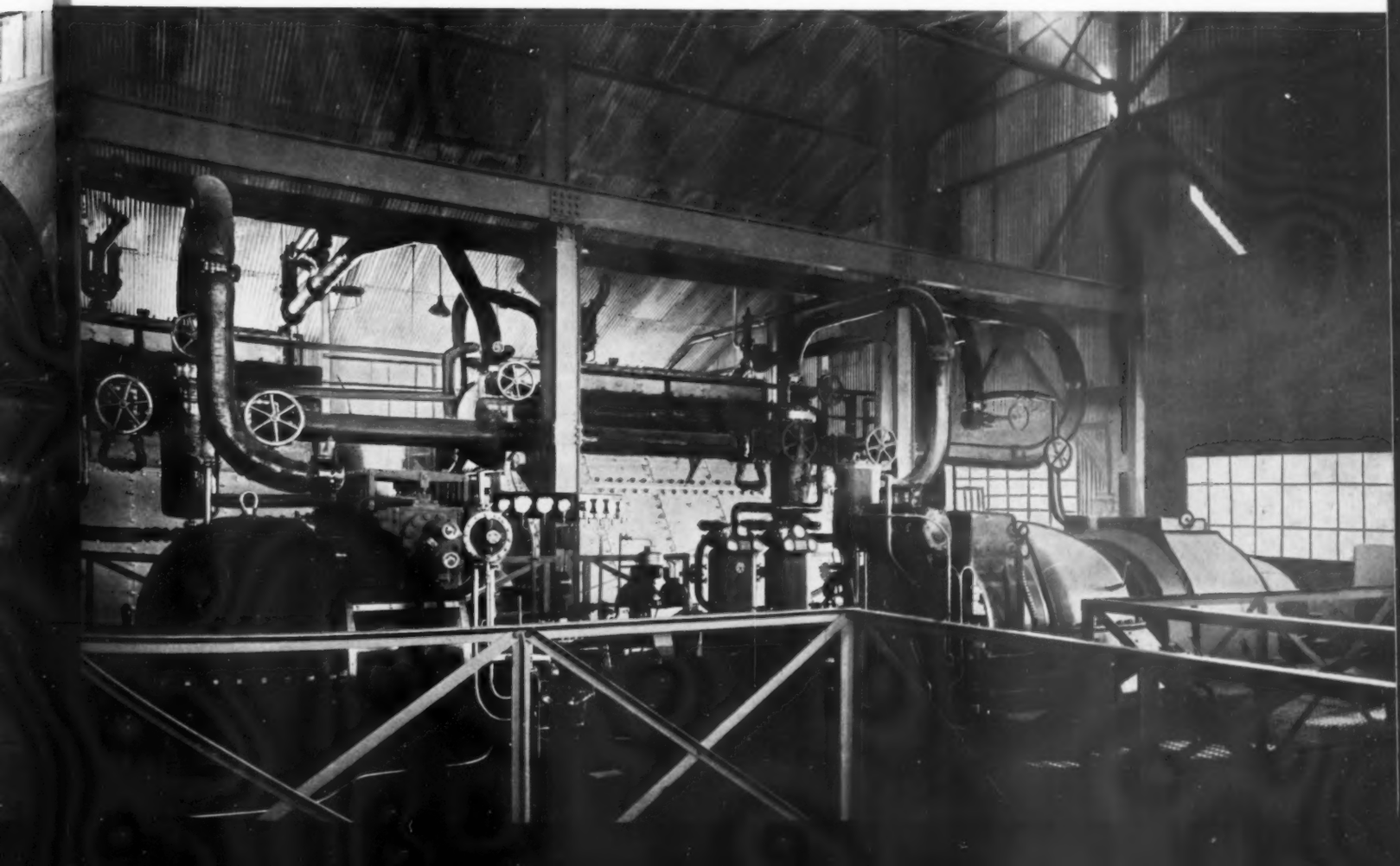
In practice, with two units in operation two pumps are in service for each duty, a third set of five pumps acting as stand-by for either of the units in service. A brief description of the five service duties is given below :—

CHARGING PUMPS.

THE charging pumps each handle 1,085 g.p.m. of pressure crude from the separators at 50-lbs./sq. inch. The nett generated pressure is 100-lbs./sq. inch, giving a final discharge pressure of 150-lbs./sq. inch. The oil reaches the pumps in a condition of saturation with lighter gases so that any reduction in pressure results in the free liberation of light hydrocarbons in a gaseous state. Very great care had therefore to be taken in designing these pumps to reduce hydraulic losses to a minimum and adequate arrangements were necessary to provide free vapour venting from the suction passages. The pump stuffing-boxes are subject to the separator pressure and have been designed specially to take a combination of metallic and semi-metallic packing. The glands are equipped with a water-smothering device in order to avoid any danger of fire owing to the liberation of hydrocarbon gases with the drop in pressure through the stuffing boxes. The pump impellers are of stainless steel.

HOT OIL RE-CIRCULATING PUMPS.

THESE pumps are of a special high-temperature design, made in the United Kingdom. They are supported on the pump centre line and located by robust transverse and longitudinal keys in order to avoid any possibility of distortion with expansion. Each pump is required to handle 1,320 g.p.m. of light topped crude at a temperature of 520 deg. F., with a suction pressure of 100-lbs./sq. inch. The pumps generate a pressure of 50-lbs./sq. inch, making a final discharge pressure of 150-lbs./sq. inch. These pumps present an unusually difficult problem because of the combination of high suction-pressure and high temperature and because the oil pumped has little or no lubricating property. A further problem is that of possible corrosion due to the presence of sulphur compounds which, whilst almost inert at lower temperatures, become increasingly active as the temperature increases. For this reason a special type of metallic packing has been adopted. The oil handled is at saturation pressure and temperature so that here again great care has been necessary to reduce hydraulic losses to a minimum. In addition to a hydraulic balancing device the end thrust is carried on a Michell thrust bearing of robust design.



Turbo-alternator Sets Generate the Power Required for the Processing Plants, and for Distant Points of Consumption.

FIRST-STAGE REFLUX PUMPS.

DESIGNED to handle 53 g.p.m. of reflux from the first-stage column, these pumps operate with a suction pressure of 100-lbs./sq. inch, and a discharge pressure of 150-lbs./sq. inch. The stuffing boxes of these pumps are of very special construction, being designed to operate continuously over long periods of service in spite of the high suction pressure and the unstable nature of the product handled.

The pumps are driven by 5 b.h.p. squirrel-cage, rotor-induction type motors.

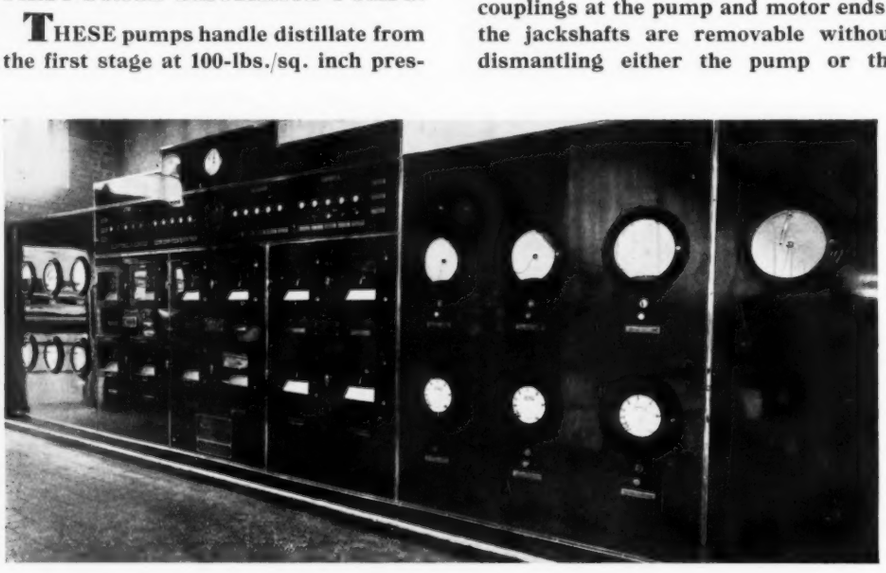
FIRST-STAGE DISTILLATE PUMPS.

THESE pumps handle distillate from the first stage at 100-lbs./sq. inch pressure and deliver into the second stage at 400-lbs./sq. inch. The distillate is similar to the reflux handled by the first stage reflux pumps and the same construction of stuffing box is used. The stuffing box problem is even more difficult on the distillate pumps because of the larger size and peripheral velocity of the stuffing box sleeves. Each pump is driven by a 70 h.p. motor.

SECOND-STAGE REFLUX PUMPS.

THE duties required from these pumps present the most difficult problem of all because the reflux is actually gas maintained in the liquid state solely by virtue of the tower pressure of approximately 400-lbs./sq. inch. It is important that there should be no escape of this liquid gas, not only because of its explosive nature, but also because of its toxic properties. The problem of operating these pumps continuously without any loss of reflux has been solved in an ingenious manner by using an extension of the external sealing arrangement adopted on the Mather & Platt stable characteristic feed pump. Each pump is required to handle 188 g.p.m. of liquid gas of specific gravity 0·485 at approximately 100 deg. F. and deliver against a pressure of 450-lbs./sq. inch. The pumps are driven by 14 b.h.p. motors.

The drive for all pumps is from jackshafts running in their own independent bearings and fitted with flexible-pin type couplings at the pump and motor ends; the jackshafts are removable without dismantling either the pump or the motor. In addition to the pumps, the whole of the electrical drive on the stabilising units was carried out by Mather & Platt Ltd., to the order of Foster Wheeler Ltd.



Instrument Panel for Controlling all Three Units.

INSTRUMENTS.

CONTROLLING and recording of plant operations are automatic as far as possible. Recording temperature controllers are installed at the base of the preflash columns, and at the top of the first stage stabilising columns, and on the inlet and outlet of the second stage reboilers.

Indicating temperature controllers control the first stage reflux supply; the first-stage column inlet and tube still inlet and outlet temperatures are recorded. Pressure controllers are installed on all columns and reflux accumulators. Flow of liquid from the base of all columns is controlled by liquid level-controllers. Pumps are equipped with indicating or recording flow-controllers, and ratio flow-controllers in the compressor suction-lines ensure equal flow to the two second-stage columns in normal operation. In addition there are numerous pressure gauges and thermometers throughout the plant.

Instruments and control panel were supplied by George Kent Ltd., and were of standard pattern in every instance; but certain detail characteristics were of necessity chosen to suit the plant's specific requirements. In order to ensure absolute reliability of service, level regulators of the internal float type were supplied for the job. All the parts exposed to oil were made of stainless steel, which was selected as suitable for crude oil carrying high percentages of hydrogen sulphide. To give the operating personnel an indication in the control-room of conditions at the separators, the regulators operate mercury switches connected to signal lamps arranged on the instrument panel.

The oil comes into the plant through three separators operated in parallel, the level being regulated in all the three separators by one regulator. As it was considered undesirable to restrict the flow from the oil wells, the level is regulated at the separator outlet. In order to cope with the conditions during a plant shut-down an emergency level regulator is mounted 4 ft. above the normal regulator. When the oil rises to the emergency level two single-beat valves are opened by the emergency regulator and the oil is discharged straight into the tanks normally taking stabilised crude.

In order to provide alternative methods of operation, the relative distribution of the oil to the three units is entrusted to two alternative instruments, a flow ratio controller and an ordinary flow controller. It is thus possible either to maintain one of the units at a constant throughput and let the other unit or units take the fluctuations or to maintain the flow through two of the units in a predetermined ratio. The arrangement of the ring main is such that any one of the units can be selected to be the one running at constant throughput.

Because it was necessary to centralise the recording temperature controllers in the control room, the choice naturally tended in the direction of thermocouple type instruments. Accordingly potentiometer recorders, fitted with pneumatic control-gear, were selected. In order not to complicate unnecessarily the control equipment this was of the simple proportional type ; but with a provision for electrically-driven reset units should these be found necessary. In fact, one temperature controller in each set was supplied complete with a reset unit.

For similar reasons provision for attaching a reset unit was made in several of the pilot-operated pressure reducing valves. It is interesting to note that the plant characteristics were found to be such that no reset units proved necessary in actual operation, excellent results being obtained by straightforward proportional control.

With the exception of the level regulators and pilot-operated pressure reducing valves, all the important instruments are grouped together and flush-mounted on a 30-ft. steel control panel housed in the control room.

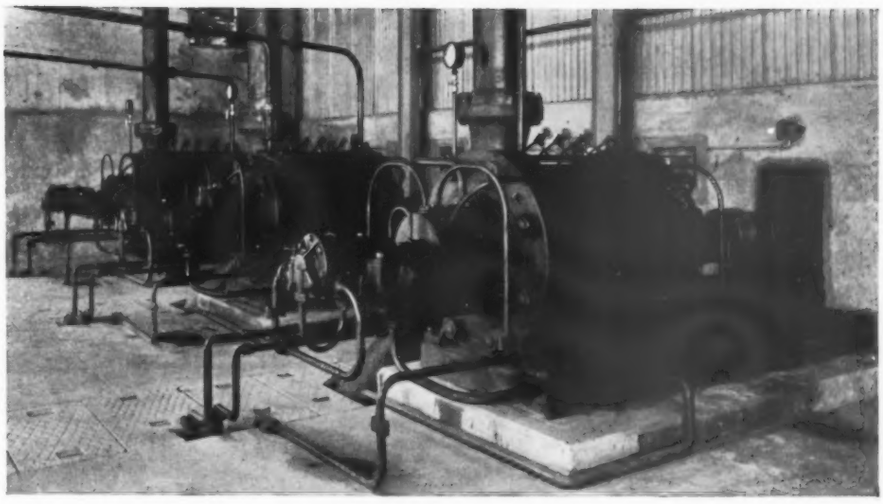
The scheme being supplied as a whole, it was possible to arrange very carefully for the air supply. Apart from the main moisture sump, the air line was subdivided into separate sections for each instrument with a separate pressure reducing valve and filter.

To take the instruments one by one, the temperature controllers are thermocouple-operated potentiometers equipped with air-operated control gear of the proportional type, but with a provision for mechanically driven reset units if such prove necessary in practice. To enable the mechanism to be swung out freely for inspection and maintenance the air is taken to and from the pilot valve by flexible metallic tubing.

The flow controllers consist of mercury type meters used with an orifice and equipped with an intercepted-jet pilot valve.

The flow-ratio controllers consist of two flow-meter units with a common front case, equipped with ratio linkwork actuating the pilot valve, and two pens recording separately the two flows.

In addition to the instruments mounted on the panel, pilot-operated pressure regulating valves and level regulators are located throughout the plant.



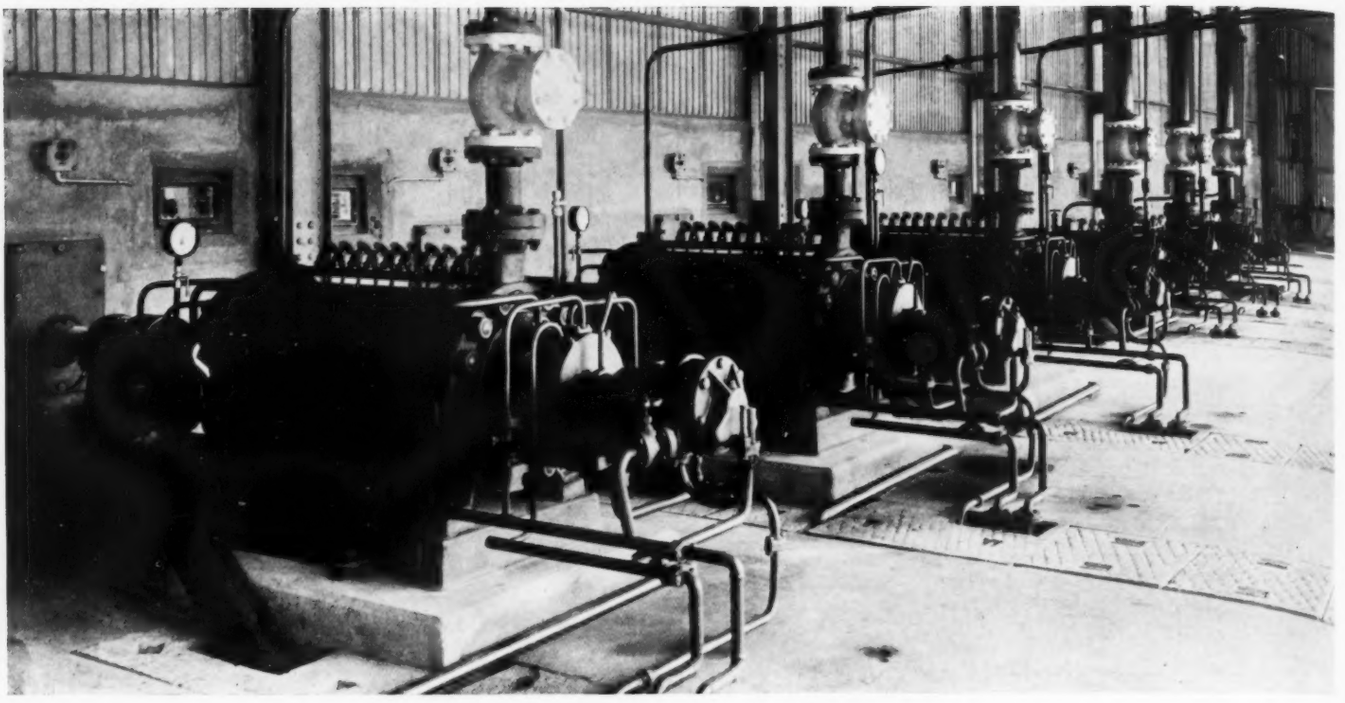
Crude-Oil Charging Pumps are Electrically Driven through Wall Boxes.

In the pressure regulating valves the mechanism is mounted on top of the diaphragm head. The mechanism consists of a nest of Bourdon tubes operating an intercepted-jet pilot valve, each unit being its own pressure reducing valve.

The control valves themselves are of the tubular body pattern with the springs completely enclosed. In order to give the most lasting service the diaphragm is made of oil-resisting material.

For those locations, where very exact pressure control is not required, direct operated control valves are employed ;

At the K-3 Pumping Station near Haditha, which is Shown During Erection, a New Foster Wheeler Topping Unit is now being Installed.



First stage distillate pumps in foreground. Second stage reflux pumps in background.

in these the pressure maintained is applied to the diaphragm head.

The level regulators are of the internal float type, i.e., with the float projecting into the actual vessel. The floats and the float arms are made of thin stainless steel. The spindles pass through grease-filled glands at either end and are carried in ball bearings mounted clear of the body of the regulator. The spindles of the regulators carry cams operating intercepted-jet pilot valves and mercury switches controlling indicating lights mounted on the control panel. To show the level maintained, a pointer working against a scale on the side of the case is provided. This pointer is made sufficiently strong to allow the operator to move it by hand and thus to feel the freedom of the movement of the float to assure himself that everything is functioning correctly. The liquid level controllers on the stabilising columns were supplied by The Fisher Governor Company.

STRUCTURAL STEELWORK.

AN elaborate system of structural steelwork was installed in order to support and provide access to the heat exchange equipment, to carry overhead all pipework with the exception of suction lines, and to give access to the numerous points of control and to the extensive manifold system. This steelwork, which amounted in all to about 250 tons, was fabricated by Wm. Neill & Sons (St. Helens) Ltd. and by the Clyde Structural Iron Co. Ltd.

CABLING.

CABLING within the process plant for power, light and instruments aggregates a length of approximately 12 miles. All main circuits to motors and light points are duplicated to minimise shut-downs.

VALVES AND PIPING.

ELECTRIC welding was used for the pipework, 85 per cent. of which was fabricated at site. All oil process valves and imported fabricated manifold piping were supplied by the Crane Company, of Chicago. The total cooling water to be circulated within the process plant under normal operation amounts to 4,500 to 5,000 gallons per minute, and the consumption of electric power is about 750 k.w. As a further indication of the size of the process plant it may be stated that the total weight of the equipment is approximately 3,000 tons and the length of piping within the battery limits about 11 miles.

POWER STATION AND BOILER PLANT.

THE boiler plant consists of two gas-fired water-tube boilers each capable of evaporating continuously under natural draught conditions 36,000 lbs. of steam per hour from feed at 120 deg. F. The working pressure is 200 lbs. sq. inch and the final steam temperature at the superheater outlet 550 deg. F. The superheaters are integral parts of the boilers. The power station equipment consists of two B.T.H. turbo-alternator sets, each set being rated at 2,000 k.w. maximum and 0·8 power-factor, together with the condensing plant and auxiliary equipment. The electric supply is generated at 3,300 volts, 3-phase, 50 cycles. The turbines are direct-coupled to the alternators and are designed to operate at 3,000 r.p.m.

The power is distributed to the process plant at 3,300 volts and 380 volts, the latter voltage being obtained by means of suitable step-down transformer sub-stations. The power to the Lesser Zab water pumping station and other distant points of consumption is transmitted at 22,000 volts by means of suitable step-up transformer sub-stations.

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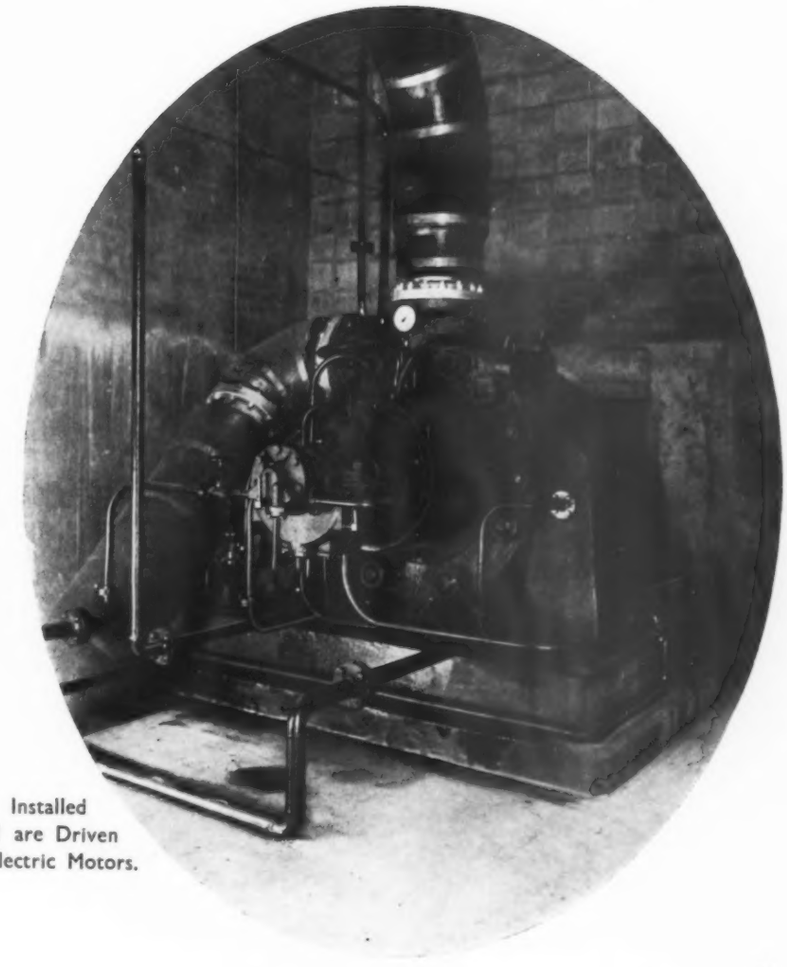
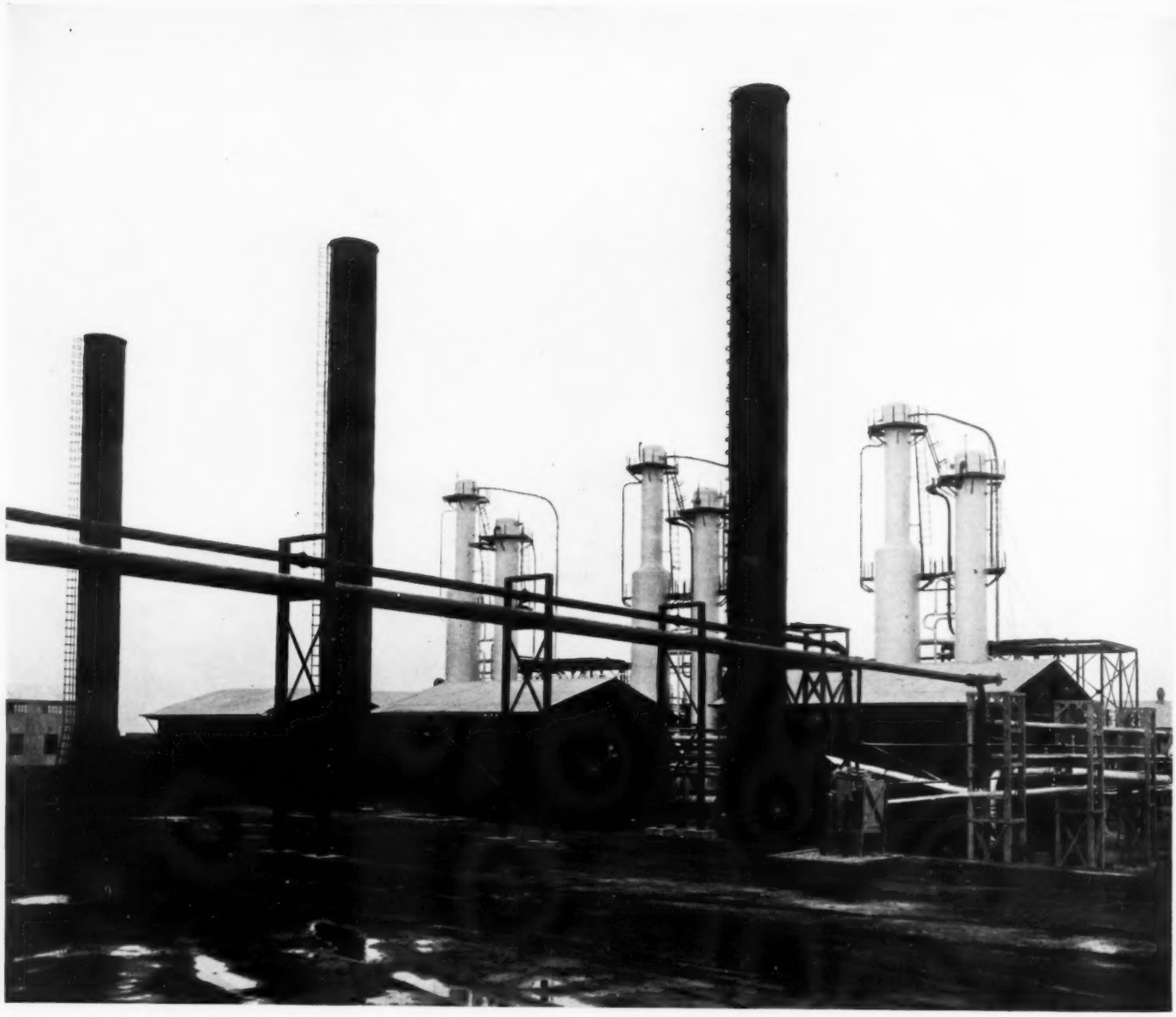
Motors for the Gas Compressors are in a Separate Room, Driving through Wall Boxes. The Compressors are Illustrated on Page 28.



All Hot-Oil Pumps are Installed in Separate Cubicles, and are Driven through Wall Boxes by Electric Motors.



Rear of the Three Tube Stills, with Stacks in the Foreground. First and Second Stage Columns can be seen in the Background.

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WATER COOLING TOWERS.

THE necessary cooling water for the turbine equipment and process plant is cooled by passage through two Mouchel type 3B hyperbolic concrete cooling towers supplied by J. C. Gammon, of Bombay. Each tower is designed to deal with 360,000 gallons of water per hour, to be cooled from 122 deg. F. to 90 deg. F. under an atmospheric wet bulb of 80 deg. F. under natural draught. The diameter of the towers at the base is 87 ft. 2 in. and the height 112 ft. 9 in.

CIRCULATING AND MAIN WATER SUPPLY PUMPS.

THE main circulating-water pumps are two in number, being of the "Medivane" split-casing type driven by 450 b.h.p. condensing steam turbines. These pumps supply the whole of the water required for condensing purposes on the stabilisation plant and are each capable of handling a maximum demand of 8,000 g.p.m. The main water supply is taken from the Lesser Zab River, which is approximately 18 miles from the plant. Water is pumped by six vertical-spindle suspended-type pumps installed in wells sunk in the gravel banks of the river. Large quantities of silt are carried in suspension by the river, but by the use of these wells all the water handled by the pumps passes through the gravel beds below the surface, with the result that it flows into the wells in a filtered state. In this manner the use of an elaborate filtration plant has been avoided. The well pumps discharge into a balancing tank and from here the water is pumped by motor-driven "Plurovane" pumps to a 2½ million gallon storage tank at the process plant. Each of these pumps is capable of handling 750,000 g.p.d. against a total head of 887 ft. The main welded steel waterline between the Lesser Zab River and the main storage tank is of 12-in. bore pipe. All the water circulating and supply pumps were supplied direct to the order of the Iraq Petroleum Company by Mather & Platt, Ltd.

FIRE FIGHTING.

THE plant has been elaborately furnished with fire-fighting equipment, two main systems being employed—the well-known "Duomixer Foamite" system and the "Mulsifyre" fire protection equipment. The "Mulsifyre" system is based on the principle of emulsification, and fire is extinguished by the formation of an oil-in-water emulsion which is non-inflammable. When the "Mulsifyre" equipment comes into operation, either automatically or by manual control, water from specially designed nozzles is discharged on to the surface of the burning oil in powerful broken streams which disintegrate the oil into tiny globules each surrounded by a film of water. Consequently a burning liquid is almost instantaneously converted into a non-inflammable emulsion.

The "Mulsifyre" installations at Kirkuk cover three distinct sections of the refining plant :—

(a) The hot-oil pump house and manifold ;

(b) The cold-oil pump house and manifold ;

(c) The compressor house manifold.

Carried from the ceiling of the protected buildings is a system of pipework to which the special water discharge nozzles are fitted in such a manner that the water discharged from them will command the whole of the floor area as well as the pumping equipment itself. This waterpipe system is coupled at each end of the building to the outlet of an automatic hydraulic valve.

The water supply for the fire-fighting installation is provided by two pumping sets, one an automatic electrically-driven set and the other a non-automatic steam turbine-driven set, both of which draw water from a reservoir of ample capacity. Each pumping plant is capable of supplying all the water required for one complete fire section. Each pump is rated to deliver 5,000 gallons of water per minute and to generate a head of 300 ft. The motor to drive the automatic pumping set is rated at 3,300 volts, 500 h.p. The steam turbine-driven pump operates on a steam supply of 200 lbs. per sq. inch, 550 deg. F.

In addition to the fire-fighting equipment mentioned above unusually elaborate precautions have been taken to avoid the outbreak of fire. Water-spray screens round the tube stills arranged at a height of approximately 6-8 ft. from the ground. These screens form an effective wall for the prevention of vapours reaching the tube stills in the event of gas leakage from any part of the plant. In addition a carefully planned scheme of air ducting for the combustion air to the tube stills is arranged for. This air is supplied by fans from a point remote from the plant so that no possibility can arise of vapours which may escape from the plant during an emergency being ignited by the tube still fires.

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Contractors' Problems

Transporting Equipment a Distance of 10,000 Miles

THE task which was set in June, 1935, was the designing and manufacturing of the equipment involved, its delivery over a distance varying from 7,000 to 10,000 miles, and the completion of erection within 15 months. The total tonnage of material shipped amounted to approximately 2,300 tons. Of this tonnage the major proportion was shipped to site via the port of Basra, involving an ocean freight through the Mediterranean and Red Sea, round the coast of Arabia and up the Persian Gulf. From Basra the equipment was transferred to rail cars, by which it was transported a distance of approximately 400 miles to Kirkuk, crossing the River Tigris en route at Baghdad. Under the most favourable circumstances transport from the United Kingdom to Kirkuk required not less than six weeks. From rail head to site, a distance of six miles, the transport involved offloading from the rail cars and reloading into lorries or tractors.

Urgent material was shipped via Haifa, one of the pipeline termini. This route enabled material to be delivered in a little over 30 days but involved trucking it across about 600-700 miles of desert and the crossing of both the Euphrates and Tigris rivers. Notwithstanding the hazards of such lengthy transport there was a negligible amount of material lost or damaged.

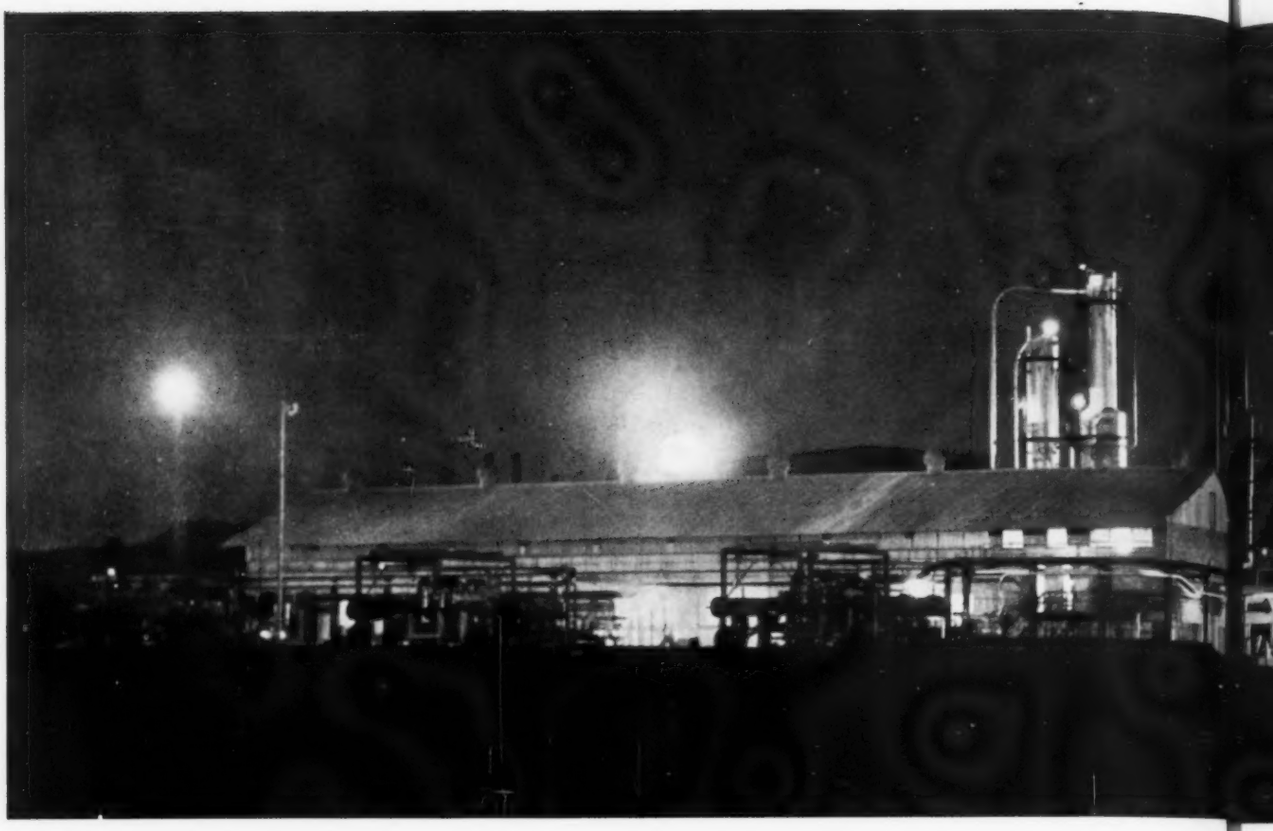
SOURCES OF MATERIALS

THE equipment and tools used in the erection work were derived from three sources of supply, viz. : the United Kingdom, U.S.A. and France. For the process plant were obtained from U.S.A. all welding pipe fittings, fabricated welded piping, horizontal reciprocating compressors, all valves for oil service and return headers for the tube stills. As before mentioned the high-pressure stabilising columns, of which there are three, were fabricated according to the latest practice by Class I electric fusion welding, and were constructed one each in the United Kingdom, U.S.A. and France. The major portion of the total tonnage was supplied from the United Kingdom and included the remainder of the pressure vessels, pumps, motors, steelworks, &c.

Throughout the construction of the plant electric welding was adopted in practically every fabricated piece of equipment. The pipe work was entirely welded and fully 85 per cent. was fabricated at site, bent and set pipes being built up by using forged steel elbows and bends. All process vessels subject to pressure were designed and manufactured in conformity with the specifications laid down in the API code for unfired pressure vessels.

ERECTION.

IN the erection of the process plant the fractionating towers, tanks and stacks were the first pieces of equipment to be received at the site and erected. The heavy lifts, of which the maximum was 40 tons weight, were handled by two derrick poles with hand-operated winches. All the heavy lifting was carried out entirely by Iraqi labour under European supervision. In spite of the language difficulty this native labour proved to be so



Night Falls on the D
The G.E.C. Flood Light astonis

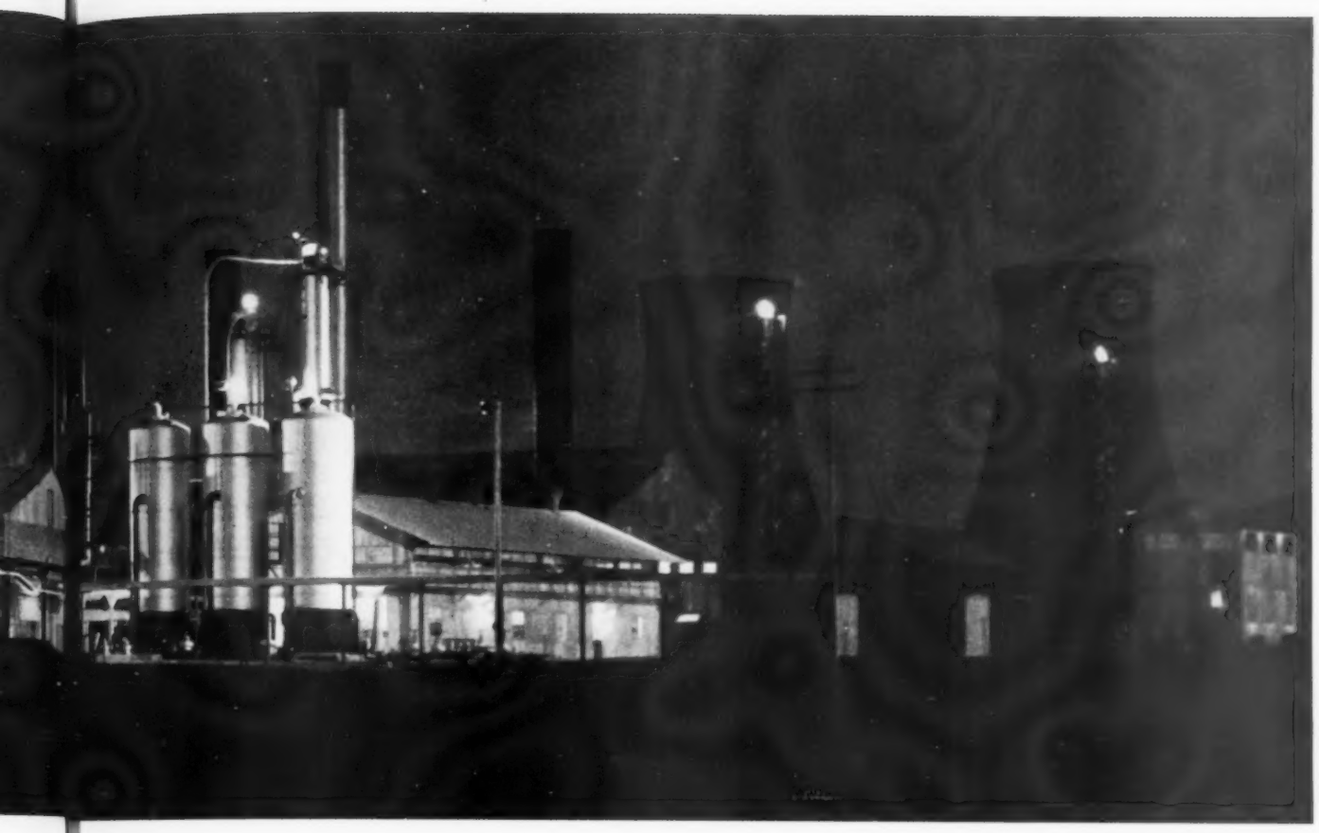
adaptable that in a very short time the lifting work resolved itself into one of the simplest problems of the undertaking. The erection of the towers was followed by that of the tube stills, structural steelwork, heat exchangers and coolers, and then by the pumps and pipe work.

Owing to the development of adverse climatic conditions locally, including the most trying winter and summer experienced there for many years, hundreds of tons of material were delayed in delivery from Basra to the site. Consequently, apart from the towers, the real erection work on the process plant had not commenced until the beginning of April, which allowed only five months until the completion date of September 1st.

During the peak of the erection period the local Iraqi labour, including foremen and skilled artisans, employed on the plant, amounted to approximately 1,600. This labour was supervised by 36 European and American specialist engineers. Towards the end of the undertaking, when longer hours had to be worked than is normal in the East, the strain on the specialist staff became very great, but fortunately the medical and housing facilities provided at the site by the Iraq Petroleum Co. proved so excellent that no undue delay occurred.

The successful completion to schedule of the vast undertaking described above is a monument to the very close and happy co-operation which exists between the Iraq Petroleum Company and its suppliers.

The crude oil stabilising plant has now been in operation for about nine months, and the technical success of the scheme may be judged from the consistency with which the plant has operated to



ght Falls a
Flood Light
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stonishes wandering Arabs.

secure the required elimination of sulphuretted hydrogen and the production of a stable crude. As a standard for commercial practice the crude oil has been considered free from sulphuretted hydrogen when this is less than 0·001 per cent. This figure has been maintained with ease. At the same time the vapour pressure of the crude oil is reduced from 80 lbs. to 5 lbs. Reid.

From the technical details of the plant given in the preceding pages some idea will be gained of the extraordinarily fine piece of work which has been accomplished. The plant itself provides a lesson in economy, for not only does it remove at the first opportunity the unwanted constituents from the crude, but it sends that crude to the refineries in such a state that its value is greatly enhanced.

From time immemorial oil has been processed in Iraq in the primitive type of plant shown on the right-hand side of the front cover of this supplement. In 1930, a Foster Wheeler topping unit was erected at Kirkuk to supply local needs ; in 1936, the crude oil stabilising plant was built, and now a new Foster Wheeler topping unit is being erected at the K.3 pumping station, the place of bifurcation of the two pipe lines to the Mediterranean. And so the work of developing the great Iraq oil field proceeds swiftly along the most up-to-date lines, demonstrating the advantages which can be secured by unified control.

Iraq, the home of oil in antiquity, is, by the wise thought which has been expended on the exploitation of its vast natural oil resource, become the most modern example of science and industry applied to the winning and treatment of petroleum.

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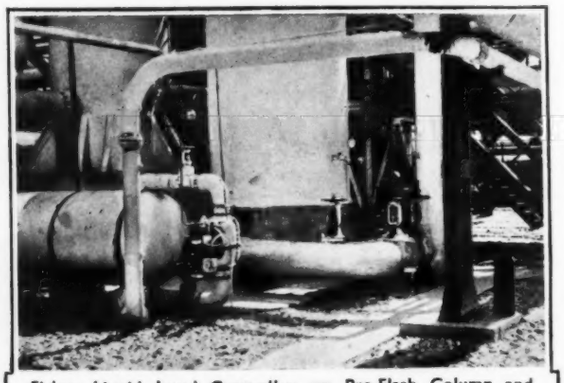
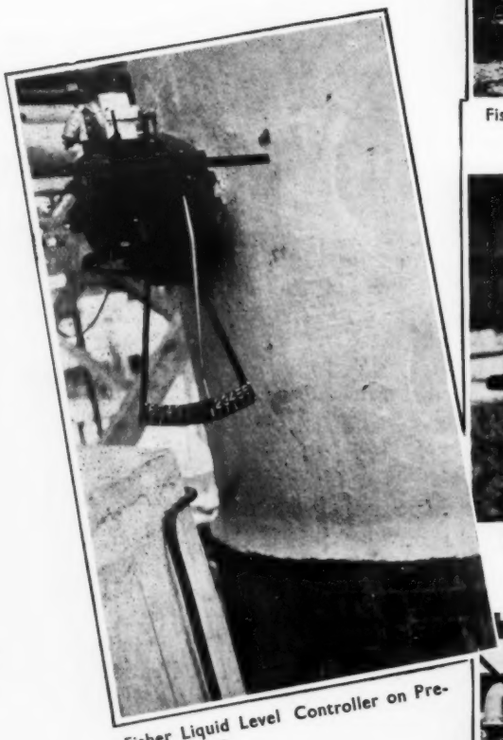
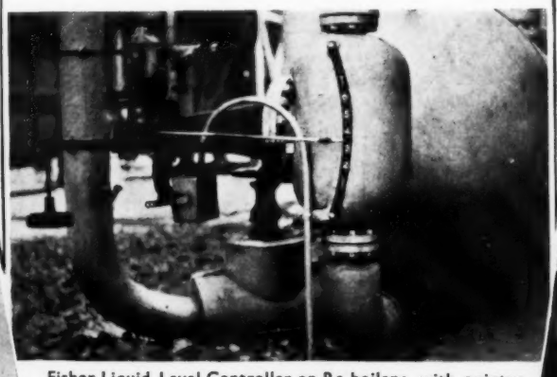


Fisher Liquid Level Controller on Pre-Flash Column and Re-boiler

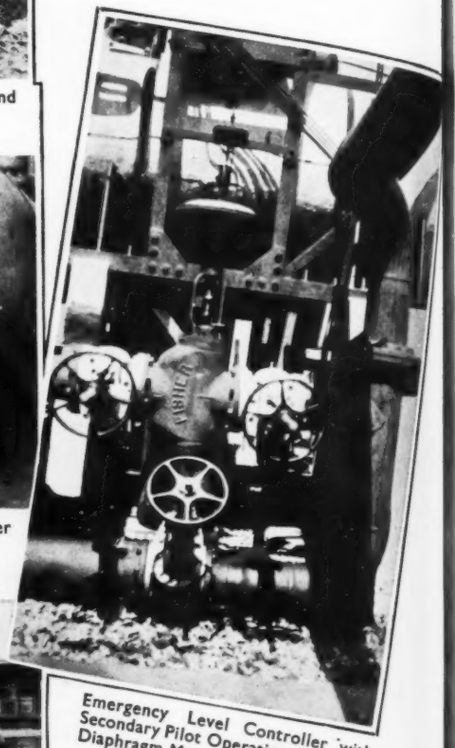
PUMP GOVERNORS AND REGULATING DEVICES



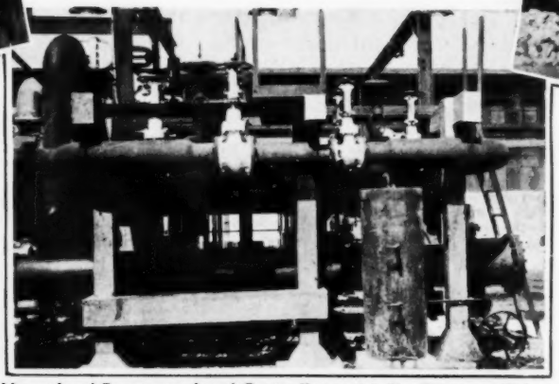
Fisher Liquid Level Controller on Pre-Flash Column.



Fisher Liquid Level Controller on Re-boiler; with pointer indicator and Mercoid Switch



Emergency Level Controller with Secondary Pilot Operating 8in. Fisher Diaphragm Motor Valve.



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